Attachment A

The Technology and Economics Of Cross-Platform Competition In Local Telecommunications Markets

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I. Introduction and Executive Summary

The Telecommunications Act of 1996 contains a complex blueprint for building a new competitive infrastructure.[1] The foundation for this new infrastructure is local competition for both narrowband and broadband services. The architects of the 1996 Act recognized that Incumbent Local Exchange Carrier ("ILEC") entry into long distance markets and other forms of deregulation would be justified only if the ILECs' monopoly local markets were opened to competition. While it is far too early to throw out this competitive blueprint, it is obvious that the high expectations at the time the Act passed have not yet been met. As measured by the degree of local competition, it is apparent that the local markets have not been opened.

The potential availability of alternative broadband platforms does not change this conclusion. The broadband market is itself highly concentrated, with many customers dependent on the ILECs. Few customers have more than two realistic alternatives. Moreover, because voice over broadband is not yet a commercial reality, even when a broadband alternative to the ILEC is available, this does not create any new competition for voice service.

[1] Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56, codified at 47 U.S.C. §§ 151 *et seq*. (1996) ("1996 Act" or "Act").

To advance the goal of competitive local markets, the Act created several mechanisms designed to create an environment where local competition could develop. One the most fundamental of those mechanisms is the requirement that incumbent monopoly local exchange carriers unbundle their networks in order to allow nascent competitors access to the incumbents' inherent economies of density, connectivity and scale.[2]

Now, six years after the passage of the Act, the Federal Communications Commission ("FCC" or "Commission") is conducting a review of the way in which competition has developed in order to determine whether or how the procompetitive unbundling measures of the Act should be modified.[3] The ILECs, of course, argue that competition is already robust. They believe they should be permitted to enter more long distance markets, to have additional services deregulated and to be freed from the basic requirements of the Act, including the fundamental requirement that they unbundle elements of their local networks for use by competitors to provide narrowband and broadband services.

The ILECs are wrong, and their position is increasingly difficult to sustain in the face of mounting evidence. As this Report shows, local exchange markets are not competitive. At the end of 2001, competitors who owned facilities that connect to end-user consumers controlled only about three percent of lines, and

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[2] 47 U.S.C. 251(c)(3). See also, *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, CC Docket No. 96-98, First Report and Order, 11 FCC Rcd. 15499 (1996) ("*Local Competition Order*"), para. 11.

[3] *In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers*, CC Docket No. 01-338, *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, *Deployment of Wireline Services Offering Advanced Telecommunications Capability*, CC Docket No. 98-147, Notice of Proposed Rulemaking, Released December 20, 2001 ("*NPRM*").

many of those competitors are facing a daunting economic future. Numerous competitive firms failed in 2001. Many of the remaining firms are in financial distress and are scaling back their expansion plans as a result.

This is a critical time for the future of a competitive local exchange market. If the requirement to unbundle the ILEC local exchange network is eliminated or scaled back at this time, before the foundation for local competition has been laid, before viable local competition has developed, the result will be the total collapse of the Act's plans for a competitive local exchange infrastructure.

Some analysts argue that "cross-platform" competition from cable television companies, wireless providers and fiber ring providers has brought competition to local markets. But the facts are otherwise. Six years after passage of the Act only a small number of residences and businesses actually have a local telephone option through their cable provider. Wireless service has not and cannot displace wireline telephone service to any significant extent, and competitive local exchange carrier ("CLEC") fiber rings do not and cannot provide a cost-effective means for reaching customers in any but the most densely populated areas. The vast majority of business customers, who are not served by CLEC fiber, have no alternative for broadband service. Residential customers have extremely limited choices, and in many cases, no choice of a broadband supplier. This outcome is obviously not competitive.

The argument that "cross-platform" competition has brought, or soon will bring, effective competition to local markets is not new. Hatfield Associates, Inc. the predecessor of HAI Consulting, Inc. ("HAI") has undertaken studies of cross-platform competition on two prior occasions. In "The Enduring Local Bottleneck," completed in 1994, Economics and Technology Inc. and HAI concluded that, contrary to incumbent ILEC claims at the time, local competition was far from a reality, and the technologies available to provide it were not ready for mass deployment.[4] In 1997 "Enduring Local Bottleneck II" focused on the consumer and small business market and found that the business case for cable and wireless alternatives for mass market voice service was not sufficiently robust to justify ILEC claims about the immediacy of local competition.[5] The passage of time has demonstrated that the bottleneck may have cracked, but it has not broken. The ELB assessments were correct. ILEC claims about the extent of competition and the viability of alternative platforms for voice services were simply wrong.

Broadband services and the Internet have undergone extensive development since the ELB Reports were completed. That fact does not change the basic industry dynamics. Large business customers rely on dedicated circuits provided by ILECs, except in the densest geographical locations where CLECs offer service over their own fiber rings. Even in these areas, many business customers are in buildings that cannot be economically served by CLECs. Many broadband customers must rely on ILEC digital subscriber line ("DSL") services because they do not yet have access to cable modems. Even where both cable modems and DSL are available, customer choice is extremely

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[4] Economics and Technology, Inc. and Hatfield Associates, Inc., "The Enduring Local Bottleneck: Monopoly Power and the Local Exchange Carriers,"1994 ("ELB I").
[5] Hatfield Associates, Inc., "The Enduring Local Bottleneck II," 1997 ("ELB II)").

Local Competition Rhetoric Versus Reality

Literally since their birth in 1984, the BOCs have been claiming that local competition is "just around the corner." Their assessments and predictions have been consistently wrong. Hatfield Associate/HAI Consulting predictions about the development of local competition, which have relied on detailed financial and technical analysis rather than massive searches for quotes from journalists or less than disinterested businessmen, have been accurate. With proper application of public policy, the BOC predictions will someday come true. But that day is not "just around the corner."

Hatfield Associates/HAI Consulting Predictions have been correct:

"Competition is likely to increase for some significant *components* of local telecommunications service over the next five to ten years under appropriate regulatory and market conditions. However, the level and scope of competitive entry is unlikely to be sufficient to eliminate or even significantly reduce the power of the BOCs. Additional time is required for effective and *sustainable* local competition to emerge."

Economics and Technology, Inc, and Hatfield Associates, Inc., "The Enduring Local Bottleneck," 1994, p. iii.

"As in the original Enduring local Bottleneck *('ELB I')* released in 1994, the findings are that competitive technologies are technologically viable. However, profitability is far in the future and internal rates of return are relatively low, except in the most optimistic cases. As a result, competition is likely to develop slowly, beginning with the more attractive markets. Residential competition may never become ubiquitous. The conclusion is that regulators cannot assume that widespread facilities competition is likely in the near term."

Hatfield Associates, Inc., "The Enduring Local Bottleneck II," 1997, p. ii.

The ILEC track record on predicting local competition is abysmally poor:

"Local exchange competition, only recently considered to be economically impossible, is now both imminent and inevitable."

Peter W. Huber, Michael K. Kellog, and John Thorne, "The Geodesic Network II: 1993 Report on Competition in the Telephone Industry," p. 2.1, quoting George C. Calhoun, Wireless Access and the Local Telephone Network (1992).

"No one can seriously doubt the financial viability of CAPS [CLECs]," p. 21.

"If cable companies in the United States experienced comparable growth of cable telephone service [in the UK], it would soon have some 45 percent of the U.S. local exchange telephone market" p. 25

. . . U.S. cable-telco alliances are now preparing to invade each others' regions." p. 26.

. . . cellular architecture is inherently expandable, like an accordion. The capacity of all cellular systems, including PCS, can be increased almost indefinitely by deploying additional cells and thereby reusing already-allocated spectrum." p. 34

"The Enduring Myth of the Local Bottleneck," 1994, (unsigned, but widely attributed to Peter W. Huber).

limited because the competitive significance of satellite and fixed wireless services is limited. The high prices of cable and DSL services force many customers who would otherwise be interested in broadband to continue to rely on ILEC dial-up lines. As a result, most consumers access the Internet through ILEC-provided dial-up lines.

Many consumers for some time to come must rely on the ILEC platform to satisfy both their local calling and Internet access needs. If these consumers are to receive the benefits of competition, it will be necessary to open the ILEC network by enforcing, and even broadening, the current unbundling and pricing rules.

This Report provides an updated assessment of the development of post-Act competition and the near term prospects for further facilities-based competition from firms using alternative technology platforms. This assessment of the potential for cross-platform competition in local telecommunications begins in Section II by reviewing the characteristics of competition among technology platforms. Section III defines various local service and geographic markets. Section IV provides a review of the current state of competition in these markets. Sections V through VII discuss the technology and economics of the alternative platforms: cable, wireless and fiber rings. Section VIII analyzes broadband deployment. Despite ILEC claims, broadband competition is limited. This section also discusses the potential for intramodal competition through CLECs using ILEC network elements to provide voice services over DSL.

The finding of these sections is that none of the platforms provides sufficient competition to limit the exercise of market power by the incumbents. At least for the near future, the markets will remain highly concentrated with, at best, an oligopoly structure that leaves consumers with limited choice. Section IX discusses the inadequacy of an oligopoly structure to bring the full benefits of competition to consumers.

The policy consequences of these conclusions are the subject of the remainder of the paper. Section X explains why unbundled network elements ("UNEs") are necessary to provide consumers with some of the benefits of competition. Unbundled loops, switching, transport and UNE platform will be necessary if CLEC and interexchange carrier ("IXC") competitors are to efficiently serve their customers. The importance of access to elements of the ILEC network to serve broadband will also be noted.

Finally, Section XI explains why unbundling will not discourage efficient deployment of either ILEC or CLEC platforms. Competitors would prefer not to be dependent on ILECs. They will build competitive facilities as market demand and economics of facilities construction allow. ILECs will also build the facilities needed to serve their customers and compete where viable competitors enter. Total Element Long Run Incremental Cost ("TELRIC") pricing adequately compensates ILECs for the risk inherent in building facilities.

II. Competition and Monopoly in Telecommunications

The first step in this analysis is to specify the characteristics of competition and monopoly and to relate those theoretical concepts to current telecommunications markets. The fundamental characteristic of competition is the ability of consumers to choose among alternative suppliers. Given this ability, each competitor has an incentive to price at reasonable levels, to provide quality service, and to deploy new technology as innovation proceeds. A firm with market power, in contrast, is able to restrict output, to otherwise limit the options available to consumers, or to prevent innovative uses of its services because consumers have a limited choice of suppliers.

The textbook economics model of competition generally assumes that technology is known and that all actual or potential competitors have access to it and can enter on a relatively modest scale.[6] Any attempts by one competitor to raise prices above cost or restrict options available to consumers will be quickly thwarted by other (actual and potential) competitors.

The textbook competition model does not apply to local telecommunications markets. Competitors cannot economically enter local markets using the same copper loop technology currently deployed by the incumbents. While the technology is known and widely available, substantial economies of scale prohibit entrants from using the technology to serve consumers.[7]

In areas with extremely high teledensities firms deploying fiber ring technology can overcome the economies enjoyed by the incumbents. However, this alternative technology platform exhibits high fixed costs per customer. These high fixed costs limit the applicability of fiber ring technology to large

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[6] See, e.g., Hal R. Varian, *Microeconomic Analysis*, 3rd ed., Norton, New York 1992, pp. 215-221.

business customers, or in some cases, multi-unit residential dwellings, in core urban areas.

If there is to be widespread local competition for the mass market, the competitors must use other technologies. Two potential mass market technologies are considered here: cable telephony and wireless. In both cases, existing competitors are serving related markets with technology that can be adapted to serve local telephone markets. Having built networks that are providing profitable services – cable television or mobile communications – these competitors enjoy potential economies of scope that may allow them to overcome the economies of scale enjoyed by the incumbents. However, as shown below, such competition is far from imminent.

The development of the Internet and the rise of broadband markets may provide another potential platform for at least partial local competition. Competitors using the Internet Protocol ("IP") may be able to compete with the narrow-band offerings of the ILECs by deploying voice service over the ILEC DSL services. The consumer will still have to, directly or indirectly, purchase a local line from the ILEC. However, an independent DSL provider working with an Internet service provider ("ISP") could supply the consumer with access to long distance services and vertical and ancillary services such as voice mail and the custom calling features often purchased by local subscribers.

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[7] ILEC economies of scale are discussed below in Section VII.

The task of the remainder of this report is to explore the ability of the alternative technology platforms to bring competition to local telephone markets. Those markets are described in the next Section.

III. Service and Geographic Markets

Markets that the Commission has previously identified in the *LEC Classification Order* and in various merger proceedings are a useful starting point for this analysis. [8] On the product market side, The Commission has properly placed residential and small business services in the same local services market and placed larger businesses in a separate market. Large businesses typically require a different set of services than residential and small business customers. The incumbents provide a number of services within these markets. In addition to the traditional local switched service purchased by households and small businesses, large businesses purchase alternative forms of dedicated access such as high capacity T1, and higher capacity synchronous optical network ("SONET") services.

The development of the Internet has led to demand for broadband transport services, typically supplied by the incumbent cable or telephone operator but provided to retail consumers by ISPs. Broadband services

[8] *Regulatory Treatment of LEC Provisioning of Interexchange Services Originating in the LEC's Local Exchange Area*, 12 FCC Rcd. 15756 (1997) ("LEC Classification Order") at para. 26 (the 1992 Department of Justice and Federal Trade Commission Merger Guidelines provide the proper analytical framework for defining relevant markets in order to assess market power).

constitute a separate economic market that is of interest in this analysis as well.[9] This point is discussed further in Section VIII below.

The geographic dimension of the market is also important. Consumers require service at their fixed locations. The availability of a competitive alternative in an adjacent community is not a substitute for the ILEC service provided at the consumer's residence. Therefore the geographic scope of local markets can be quite narrow. For example, the Commission has found that each point-to point market may constitute a separate geographic market.[10]

Even within a metropolitan area, there may be separate geographic markets. Some large businesses will have no choice of suppliers while others, for example those along a particular street where CLECs have laid fiber, may have several choices. Defining a metropolitan market will not be useful in answering the question of whether market power can be exercised. The CLEC competitors serving some buildings in the city center have no effect on the ability of the ILEC to exercise market power even in adjacent neighborhoods..

Some customers may require service at several locations within a metropolitan area. For example, some large businesses require local networks that link separate locations together. Serving these customers efficiently requires a geographically diverse local network. Thus, even where a competitor has loop facilities to serve one or more of such a customer's locations, that competitor is

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[9] *In the Matter of Applications for Consent to the Transfer of Control of Licenses and Section 214 Authorizations by Time Warner Inc. and America Online, Inc., Transferors, to AOL Time Warner Inc., Transferee*, CS Docket No 00-30, Memorandum Opinion and Order, FCC 01-12, Released January 22, 2001 ("*AOL/Time Warner Merger Order*"), para. 56.
[10] *Ibid*., para 74.

not necessarily in a position to supply the customer's full local telecommunications needs with its own facilities. Such a competitor cannot adequately compete for the business of such a customer unless UNEs are available at competitive prices.

In U.S. Department of Justice Merger Guidelines terms, a firm with a monopoly over large portions of a metropolitan area can raise and maintain prices for some time even though other firms may operate in some portions of the same metropolitan area.[11] The dominant firm may be able to raise and maintain prices paid by customers that require connections throughout the area.

IV. Current Competition Metrics

This Section analyzes the level of current competition and compares the development of local telephone competition with the evolution of long distance competition. The conclusion is that local competition is still limited, and progressing much more slowly than did long distance competition.

A. Market Share Analysis

According to the FCC, the CLEC share of the local telephone business grew to 9 percent by mid-2000.[12] However, this share is composed of both "CLEC-owned" lines and lines acquired from ILECs (resale or UNE lines).[13]

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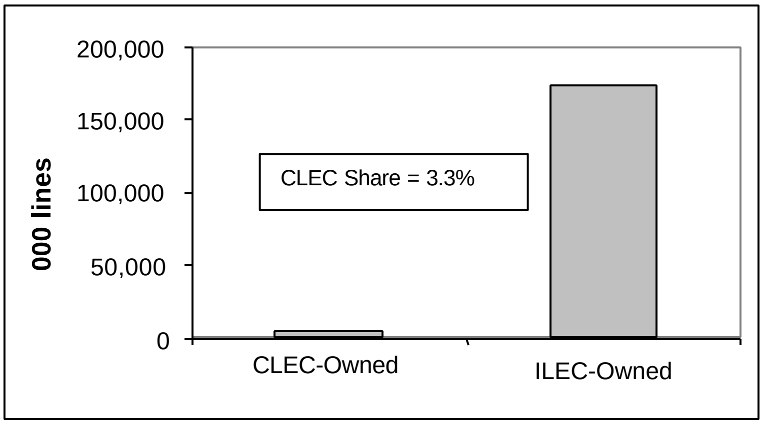
[11] "Horizontal Merger Guidelines," U.S. Department of Justice and the Federal Trade Commission, issued April 2, 1992 and revised April 8, 1997.
[12] FCC, "Local Telephone Competition: Status as of June 30, 2001," Industry Analysis Division, Common Carrier Bureau, released February 2002 ("Local Competition Report"), Table 1.
[13] Economists writing on behalf of the ILECs have used the growth of total CLEC lines to argue that competition is robust. See, *e.g.*, Robert W. Crandall, "An Assessment of the Competitive Local Exchange Carriers Five Years After the Passage of the Telecommunications Act," June

Looking only at lines provisioned over their own loop facilities, CLEC market share is only 3.3 percent, a moderate increase from the 2.9 percent share they had at the end of 2000.[14] See Figure IV.1.

Figure IV.1
CLEC/ILEC Owned Lines



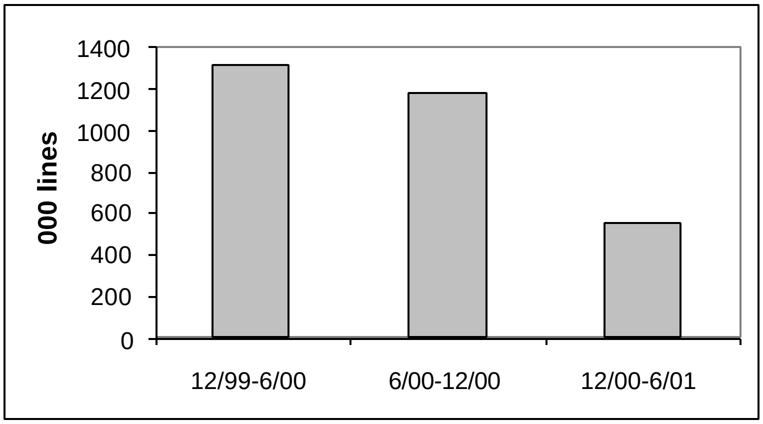
The growth trend for CLEC lines is also of interest. Recent FCC statistics show that local competition is growing but at a decelerating rate. As shown in Figure IV.2, CLECs added 3.4 million lines in the first half of 2000, 3.3 million lines in the second half of 2000, and only 2.4 million lines in the first half of

2001 ("Crandall"), p. 4. The problem is that the most robust growth in lines is coming from the UNEs that their clients want to eliminate.

[14] *Ibid*. Data for the FCC's Local Competition Report are collected through a semi-annual survey. The results for mid-year 2001 were released in February 2002. The FCC reports 5.8 million CLEC owned lines as of June 2001. The total number of lines in the market was 192 million, resulting in only a 3.0 percent share for competitors owning their own "last mile" facilities. See Local Competition Report, table 3 and 4. There is a bias in the FCC's survey that may lead to an understatement of both ILEC and CLEC lines. A firm is required to respond only if it has 10,000 or more lines in a state. However, it is difficult to determine the direction of the bias. The FCC notes that, " . . .the reporting ILECs account for about 98% of all ILEC lines." [fn. 5 at p. 2] The question then is whether CLEC lines are under reported to a greater extent. It seems likely that the survey responses include most of the CLEC facilities lines. Larger CLECs are more likely to own facilities connecting end users. Constructing facilities to connect end-users is a capital intensive business and the larger CLECs are more likely to be doing it. Moreover, the FCC notes that, " . . .24 CLEC reports were from carriers that had fewer than 10,000 lines in a particular state and were thus voluntary." [fn. 6 at p. 3] The Commission also suggests that some CLECs may have reported lines as being owned even though they did not provide the "last mile." [fn. 3 at pp. 1-2]

2001.[15] The second half of 2001 data are not available. However, given the financial problems of the CLECs in this period (discussed in Section VII.D below), this deceleration in growth likely continued.

Figure IV.2
CLEC-Owned Line Growth



Most CLEC-owned facilities serve larger businesses. As Figure IV.3 shows, only one third of the CLEC-owned lines are provided by cable companies.[16] The bulk of the remaining owned-facilities lines are undoubtedly provided to large business customers over the fiber ring platform.[17]

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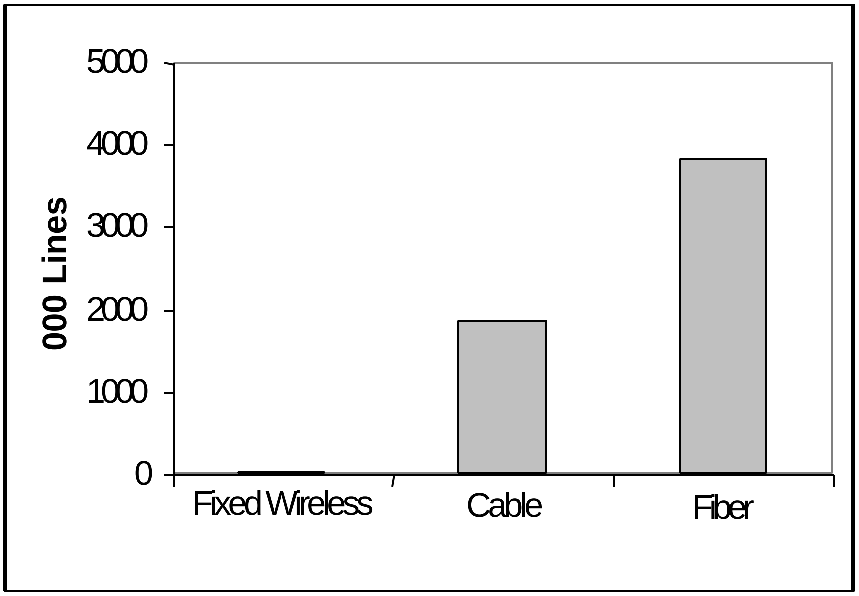
15 Derived from Local Competition Report, Table 1.
16 See, Local Competition Report, Table 5.
17 As discussed in Section VI.B, there are undoubtedly some customers that have replaced their local fixed lines with mobile service. However, the numbers are small due to the inherent limitations of wireless service. Moreover, wireless capacity is simply inadequate to support significant traffic that is currently carried on fixed networks.

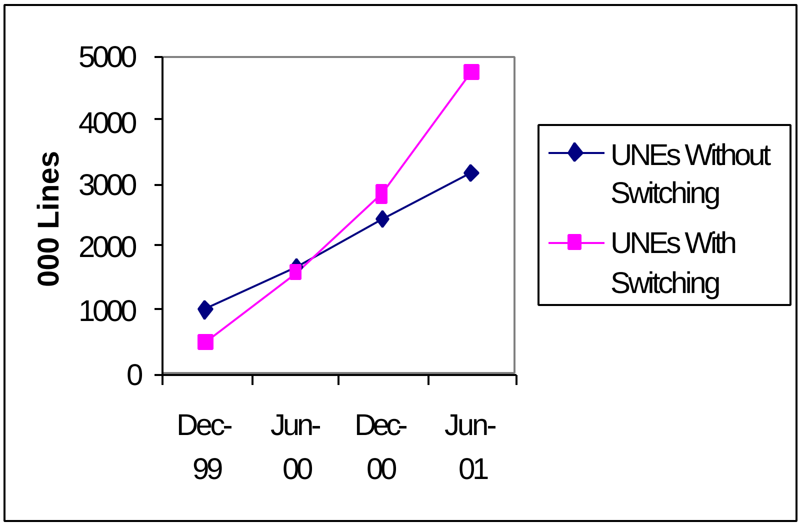
Figure IV.3
CLEC-owned Lines by Type



There is one category of lines that is showing impressive growth. As shown in Figure IV.4, UNEs with switching, which represent the UNE platform ("UNE-P"), increased by 68 percent from December 2000 to June 2001, while stand-alone UNE loops increased by only 30 percent. This likely reflects the successful introduction of UNE-P competition in Texas and New York.[18]

[18] Local Competition Report, Table 4.

Figure IV.4
UNE Line Growth



Of course, market share is not the only metric on which the presence of competition can be judged. The competitive significance of the CLECs can also be illustrated by looking at the capability of their networks to serve additional customers. This metric is discussed in the sections dealing with the cable, wireless and fiber loop platforms below. The basic conclusion that the extent of local competition is limited does not change.

B. Comparison to the Evolution of Long distance Competition

The growth of local competition might also be compared to the way competition developed in the long distance industry. As noted above, six years after passage of the 1996 Act, competitors have about three percent of the lines. Long distance competition was much greater six years after competition in the long distance market began.

It is difficult to date the commencement of long distance competition. Toll service competition began in approximately 1978 with the Execunet Decisions,[19] but long distance competitors were not put on an equal footing with AT&T until equal access conversions began in 1984. Nevertheless, by the end of 1984, six years after the Execunet II Decision, and at the very beginning of the equal access conversion process, AT&T had lost nearly 20 percent of the toll market based on minutes.[20]

Competitors made rapid gains after equal access conversions began in earnest. By 1990, six years after Divestiture, competitors had captured about 37 percent of the toll market based on minutes and 25 percent based on lines.[21] These results are shown in Table IV.1.

Table IV.1
Local Versus Long Distance Competition

	Market Share – Lines	Market Share – Minutes
IXCs -- Execunet plus six years	n/a	20%
IXCs -- Equal Access plus six years	25%	37%
CLECs -- 96 Act plus six years	3.3%	n/a

Another way to gauge the relative extent of competition is by observing pricing performance. Inflation-adjusted long distance rates have fallen by approximately 80 percent since 1983, the year prior to Divestiture. ILEC rates

[19] *MCI v. FCC*, 561 F.2d 365 (D.C. Cir. 1977) ("*Execunet I*") and *MCI v. FCC*, 580 F.2d 590 (D.C. Cir. 1978) ("*Execunet II*").
[20] See, FCC, "Long Distance Market Shares Fourth Quarter 1998", Industry Analysis Division, Common Carrier Bureau, March 1999 ("IXC Market Share Report"), Table 1.1, pp. 1-2, and Appendix 1, Chart A1.1, p. 29.
[21] *Ibid*., Table 2.2.

are essentially unchanged over the same period.[22] The cost of electronic components, including switching and multiplexing equipment, all significant components of ILEC networks, have plummeted since 1983. However, consumers of ILEC services have not shared in the benefits of those cost reductions.

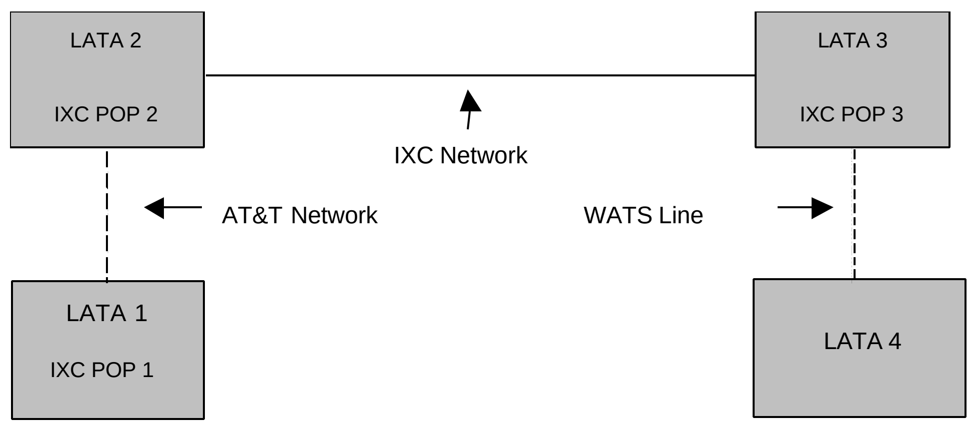
It is important to note that long distance competitors were able to grow rapidly in large part due to the Commission's resale policies. Competitors were able, over AT&T's objections, to "fill out" their networks by reselling AT&T private-line or wide area telecommunications services ("WATS").

As shown in Figure IV.5, AT&T's IXC competitors could originate traffic from off-network locations using AT&T private-lines and offer ubiquitous terminations through WATS resale while their own networks were being completed. For example, an IXC could establish a point of presence ("POP") in local access transport area ("LATA") 1 and originate calls from its customers using an AT&T private-line to carry the call to LATA 2 where the IXC had already built transmission facilities. If the call was destined for LATA 4, where the IXC had no network, and had not yet established a POP, the call could be completed over an AT&T WATS line. In this way the IXC could sign up customers in advance of constructing its own facilities, as well as offer customers ubiquitous terminations. In terms of the 1996 Act, the WATS line filled the role of interconnection while the private-line filled the role of a UNE. The result was the

[22] See, Declaration of Lee L. Selwyn, In the Matter of Application by Verizon New Jersey, Inc., for Authorizxation to Provide In-Region, InterLATA Service in NewJersey, CC Docket No. 01-347, February 28, 2002, p. 25.

development of a vigorously competitive long distance market. Today competitors have established POPs in, and built facilities to, virtually all of the 200 plus LATAs in the United States.

Figure IV.5
IXC Resale



Even today the degree of competition in the long distance market is enhanced by the fact that smaller carriers are able to extend their networks through buying capacity from, or reselling the services of, the larger carriers. Competition in the long distance market has evolved to the point that the larger competitors willingly sell capacity to smaller carriers, knowing that in the competitive environment they face others will do so if they do not.

C. Conclusion

There is little local competition today. Fiber carriers have made some inroads into the large business market in limited (but important) geographic niches. However, the rate of growth of facilities competition is slowing dramatically. Residential and small business competition is minimal. Moreover, as discussed below in Section VII.B, there are significant numbers of large business customers that do not and will not have alternatives available. The following sections demonstrate that significant competition from these alternative technology platforms is at least several years away.

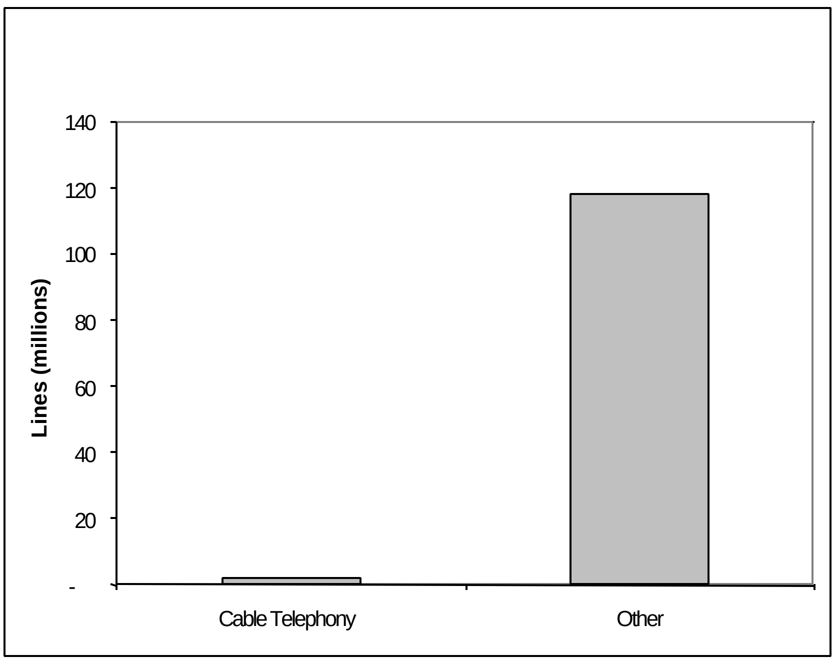
V. Cable Telephony

This section examines the current cable telephony landscape and the prospects for the future development of cable telephony service offerings. The discussion of cable telephony is divided into four sections. Cable telephony providers are identified in Section A. While these providers are making significant inroads in some service areas, their national impact is limited. The business considerations that explain the low cable penetration are discussed in Section B. As discussed in Section C, the business calculation could change when IP voice telephony is implemented. However, that technology is not yet ready for commercial deployment. Finally, as discussed in Section D, cable telephony is not an adequate substitute for the local services purchased by larger businesses. In sum, the overall conclusion of this section is that development and implementation of cable telephony technologies does not yet represent a significant competitive threat to ILEC networks.

A. Existing Cable Telephony Providers

In June of 2001, the cable industry served approximately 1.9 million access lines, which yields a penetration of 1.6 percent among residential and single line business customers.[23] In other words, cable telephony is providing only 1.9 million of the roughly 118 million residential and small business access lines in the U.S. A comparison of cable telephony lines to other local lines is shown in Figure V.1.[24] The cable industry provides service to almost no large business customers and its share of the small business and residential local access market is insignificant.

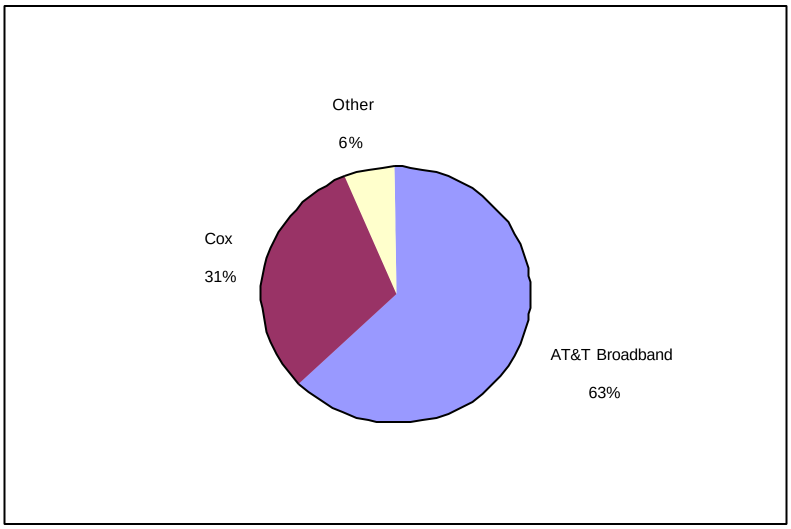
Figure V.1
Cable Telephony Market Share



[23] Local Competition Report, Table 5.
[24] Estimated residential and single line business lines as of June 2001. These lines are estimated by adjusting year 2000 data from FCC ARMIS Report 43-08 for all reporting local exchange carriers one year forward based on the historical trend for the same data series between 1999 and 2000. This number is then added to the estimated number of cable telephony lines in service to arrive at the total residential and small business line estimate.

The two largest cable telephony providers offering service today are AT&T Broadband and Cox Communications. AT&T provides 63 percent of cable telephony service, or about one million subscribers.[25] Cox serves the second largest number of subscribers, about 500,000, or 31 percent.[26] Cablevision and a few other cable operators with limited telephony service offerings serve the remaining 6 percent of cable telephony subscribers. Cable operators representing roughly 65 percent of the industry are not aggressively marketing telephone services.[27]

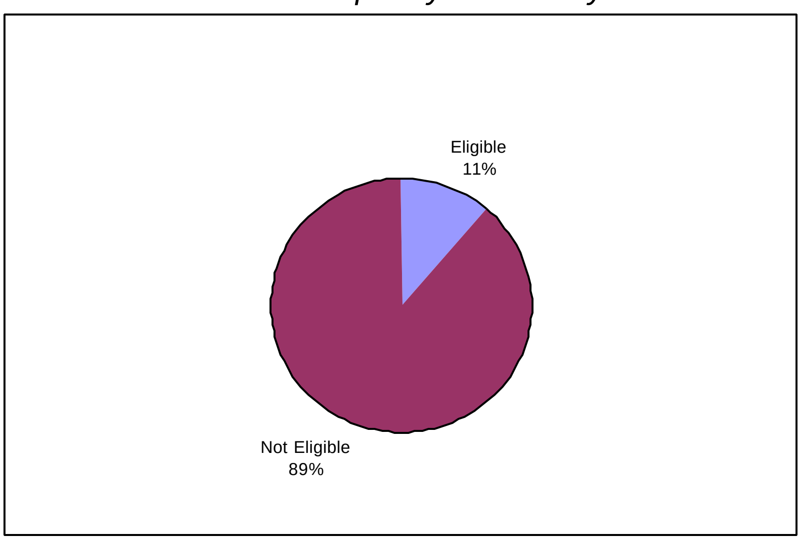
Figure V.2
Cable Telephony Providers



[25] AT&T News Release, "AT&T Announces Fourth-Quarter Earnings," January 30, 2002 "AT&T News Release, 1/30/02"), http://www.att.com/press, viewed March 13, 2002.
[26] Cox Press Release, "Cox Communications Announces Fourth Quarter Financial Results for 2001," February 12, 2002 ("Cox Press Release, 2/12/02"). http://www.cox.com/PressRoom, viewed March 13, 2002.
[27] AT&T and Cox serve 35 million of the roughly 99 million cable television homes passed. AT&T Form 10-Q For the quarterly period ended September 30, 2001. Cox Communications Inc., "Consolidated Historical and Pro Forma Statements of Operations," For the quarter ended September 30, 2001. Available at: http://www.cox.com/PressRoom/Q3%202001%20Earnings% 20Release.asp, viewed March 14, 2002. National Cable Telecommunications Association ("NCTA"), "Cable and Telecommunications Industry Overview 2001," p. 16, table entitled, "Cable Industry Facts-At-A-Glance (December 2001)," referencing Paul Kagan Associates, Inc. as source for "Homes Passed by Cable" data.

Even when a cable company is marketing cable telephony service, many of its customers do not have access to the service. Network upgrades do not render all homes "telephony-ready." Cox is the oldest, most aggressive and most successful provider of cable telephony service in the US. Their fraction of telephony-ready homes passed to total homes passed likely represents a reasonable upper bound for the percentage of plant any larger operator might have supporting telephony services. As of September 30, 2001, Cox reported approximately 3.1 million telephony-ready homes out of 9.9 million total homes passed, for a penetration of 32 percent.[28] Applying this percentage to AT&T's total homes passed, and adding a gross up for the other cable telephony providers yields 11.7 million telephony-ready homes, or approximately 11.3 percent of the 103 million telephone households across the U.S. See Figure V.3.

Figure V.3
Cable Telephony Availability



[28] *Ibid*., Cox Communications Inc., "Consolidated Historical and Pro Forma Statements of Operations," For the quarter ended September 30, 2001.

Of course, availability and penetration are much higher in particular cable telephony serving areas. The purpose of this exercise is to demonstrate the level of competition offered by cable telephony providers on a nationwide basis, and it shows that impact to date is minimal and will likely remain so for some time to come.

Cable telephony offers competition to the incumbent local exchange carriers only on a limited basis. The cable telephony competition that does exist is concentrated in certain service areas, and thus leaves a significant portion of residences and small businesses without a competitive local exchange offering from their cable television provider. The explanation for this low penetration is provided in the next section, which examines the business considerations cable operators face when they decide whether to invest in cable telephony.

B. Cable Operator Investment Alternatives

Investment in telephony by cable operators has been inhibited by a number of factors, including competing revenue opportunities, uncertainty over potential revenue and technological uncertainty. The factors identified in this section, which include network upgrade costs, the potential for competitive response from incumbent carriers, broadband and wireless substitution, and the perception of better returns on cable provision of digital television ("DTV") and broadband data investments show that significant risk is associated with cable telephony investment.[29] These issues are discussed in Sections 1 and 2. The

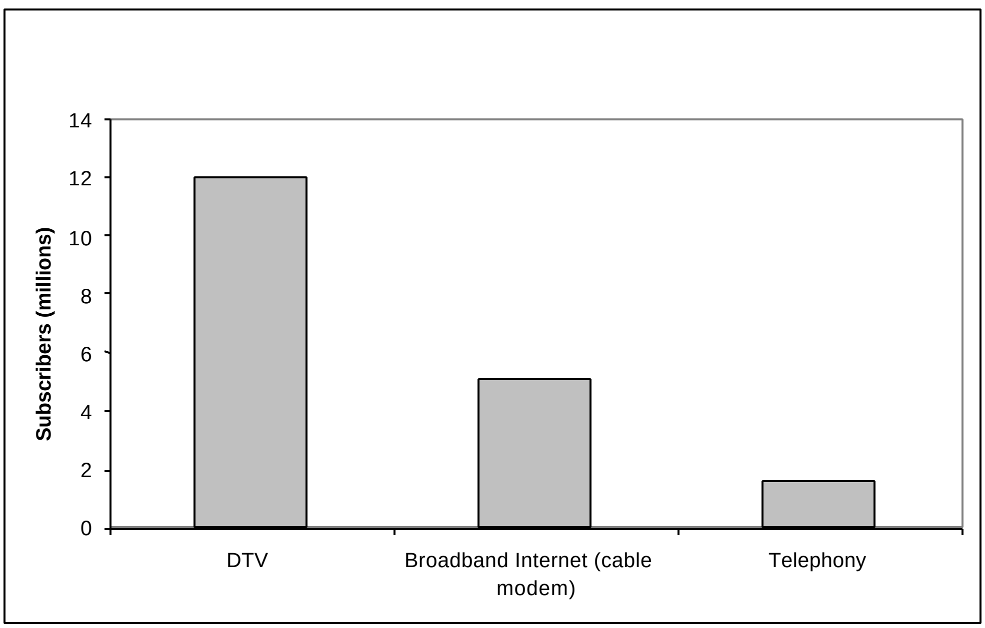
[29] HAI identified and quantified these risks in ELB II.

additional uncertainty caused by the potential for superior IP telephony technology to become available in a few years is discussed in Section C.

1. Competing Investment Alternatives

Although numerous multiple system operators ("MSOs") have proceeded with the expensive network rebuilds or upgrades that add capacity and two-way capability to their systems, many operators are not aggressively pursuing telephony. Instead, most MSOs are using their upgraded networks to offer DTV and broadband Internet access, also called cable modem service. Examining the relative penetration levels of these services emphasizes this point, as shown in Figure V.4.

Figure V.4
Advanced Service Penetration, June 2001[30]



[30] *In the Matter of Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming*, CS Docket No. 01-129, Eighth Annual Report, Released Jan 14, 2002 ("*8th Annual Video Programming Report*"), pp. 19-28 and HAI estimates. Telephony penetration estimate, year-end 2001. Cox "ended 2001 with nearly half a million telephone customers…,"

There are several reasons why MSOs are more interested in DTV and cable modem service than primary line telephone service. In the mid-late 1990's many MSOs experimented with cable telephony by offering service trials. The high incremental cost of service provision, the promise of forthcoming technologies that would reduce cost and simplify operations, and the perception of better revenue opportunities through other advanced services led most MSOs to shelve their circuit switched telephony rollout plans.[31] Cox Communications was one of the few exceptions.

Additionally, MSOs saw revenue opportunities in other lines of business, such as DTV and broadband Internet access. Compared to telephony, these services are less costly to deploy, there are fewer competitors, and there was significant pent-up demand for high-speed data. Furthermore, DTV and broadband Internet did not require the same level of plant integrity as telephony, since the average customer was tolerant of occasional service outages for television and residential data services. Table V.1, which is based on cable industry estimates, shows the incremental costs of adding the various services beyond the cost of the basic network upgrades.

Cox Press Release, 2/12/02. At the end of 2001, "AT&T Broadband had more than 1.0 million broadband telephony customers…", AT&T News Release, 1/30/02.

[31] In the mid-late 1990's Time Warner Cable, the nation's second largest MSO, had planned to offer circuit switched cable telephony to its subscribers. Those plans never became a reality outside of a few trial communities. Today, Time Warner Communications is experimenting with IP telephony as a "second line" service. Other large MSOs, such as Charter Communications are also testing IP telephony systems in lieu of offering circuit switched telephony, which could be deployed today. See, CED Magazine, "Cable Telephony: Ready to Take Off," May 1997; and Time Warner Cable Press Release, "Time Warner Cable Expands Internet Telephone Test to Rochester Road Runner Customers," January 31, 2001.

Table V.1
Per Subscriber Incremental Cost of Service Provision[32]

Service	Incremental Cost	Includes
Digital Television	$250	Set top converter and Installation
Broadband Internet	$160	Cable Modem, Cable Modem Termination System, Installation
Telephony	$500+	Customer Interface Unit, Host Digital Terminal, Installation, Backhaul to Switch

These costs are in addition to the expensive rebuild or upgrades for the networks on which these services ride. Upgrades typically increase the channel capacity of the cable network and often include the activation of a return path, to allow two-way communications. Upgrades may also include the addition of equipment that will allow the cable operator to power customer premises equipment through the cable network. This equipment insures that cable telephony subscribers will not lose telephone service during power outages. The cost of such upgrades vary depending on the condition of existing plant, but typically range from $150-$350 per home passed. The cable industry has invested billions in upgrading plant in recent years.[33] But the alternative, providing advanced services over a cable system that has not been upgraded, if possible at all, requires even more investment.

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[32] Incremental cost of adding service to a network that has been upgraded to support these services. In the case of telephony, this necessarily implies two-way active plant. Although an activated return path is not required for broadband Internet or DTV service, both services are typically deployed on such plant. Presentation by Greg Braden, AT&T EVP, Broadband Services at the University of Colorado, Boulder, November 27, 2001, and HAI estimates. ("Braden Presentation")

[33] See, NCTA, "Cable & Telecommunications Industry Overview 2001."

2. Pressure on Telephone Revenue

Current pressures on local telephone service revenue may also affect a cable operator's decision to offer a telephony product. These pressures come from several sources including ILEC ability to lower the price of certain services, competition from wireless service providers, declining long distance prices, and the impact of broadband data on second line take rates.

Cable operators who offer telephony services typically price their services ten to twenty percent below the incumbent. The savings are greater for customers with more expensive telephone service. For example, in Denver, Colorado, Qwest offers unlimited local calling with a basket of enhanced features for $32.95. A comparable service package from AT&T Broadband is priced at $27.50, a savings of 17 percent.[34] A basic local service package from Qwest, with no enhanced features is priced at $14.92 with a $35 installation charge. AT&T Broadband's basic local service is $14.00 with free installation, a monthly savings of 6 percent. This pricing strategy suggests that AT&T Broadband is pursuing mainly those subscribers who purchase high-margin vertical features.

Table V.2– Local Service Pricing

Service	Qwest	AT&T Broadband	Savings
Unlimited Local	$32.95	$27.50	17%
Unlimited Local with Feature Pack	$14.92	$14.00	6%

[34] AT&T "Basic Local Only" plus the "Multi-Feature Pack," https://securebb.att.com: 443/services/pricing/PricingTelephonyDetail, viewed March 13, 2002. Qwest "CustomChoice" value package, http://www.qwest.com/pcat/for_home/product, viewed March 13, 2002. Both AT&T and Qwest rates are quoted for residential services.

Business cases predicated on such pricing strategies may leave cable operators in a vulnerable position. Should competition from cable operators develop to any significant extent, the incumbent could lower prices for vertical services, thereby counteracting the financial incentive offered by a competing cable telephony service provider. The ILECs have this option because the price of vertical features far exceeds the cost of provision.[35] In addition, it is likely that the incumbents could lower the price of basic local telephone service in certain geographic locations in response to a lower-priced offering from a cable telephony operator. The results of local telephone economic cost models suggest that the ILECs could substantially lower the price of their local service offerings in many areas.[36]

Another threat to the revenue-generating capacity of a cable operator's telephony product stems from reduced demand for second line demand. Significant numbers of households are replacing second lines with either wireless phones or broadband Internet access.[37] Selling second lines is highly profitable for a cable operator because the incremental cost of adding a second line to an existing subscriber is low relative to the prices generally charged. The reduced demand for second lines can have a substantial negative effect on the business case for providing telephony in a cable system.

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[35] Vertical features, such as distinctive ringing, call waiting, and three-way calling are typically included in the software bundle provided by the switch vendor. In addition, switch capacity today is not processor limited; rather switches run out of capacity when their ports are exhausted. Because vertical features are included in the switch software bundle, and today's switches are not processor limited, the cost of providing vertical features is minimal.

[36] See, HAI local exchange proxy cost model, "HAI Model, Release 5.0a," filed with the FCC on February 16, 1998 ("HAI Cost Proxy Model"). Release 5.0a is available from the International Transcription Service, Washington, D.C.

Finally, given the recent reductions in long distance pricing and usage, potential net revenue generated via the resale of long distance service and through access charges is falling. This will have a negative impact on the revenue generated by a cable telephony service offering.

Each of these factors – the potential for targeted ILEC competitive responses, reduced second line demand, and falling long distance margins – reduce the incentive of a cable operator to invest in cable telephony.

C. The Promise of IP Telephony

Today, all commercially deployed cable telephony is provisioned on circuit-switched networks, which involves dedicating a certain portion of the cable television network to the carriage of voice conversations, and routing calls through conventional switching equipment. Internet Protocol (IP) technology can also be used to carry voice over cable networks.

Some observers believe that this approach, known as IP telephony, or Voice over IP ("VoIP"). is more appealing than circuit switched telephony because it is possible to leverage the investment in equipment at the subscriber location among multiple services and to utilize bandwidth on the network more efficiently.[38] However, despite many years of development the technology is still not ready for deployment. To date there are no serious commercial implementations of cable IP telephony service. Cable operators that wish to

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[37] JP Morgan, "Telecom Services 2001," November 2, 2001, pp. 41-42.
[38] In an IP telephony implementation, cable modem and telephony functions may be integrated in a single subscriber device. Because the underlying data transport is shared between telephony and data services, economies of scope can be realized.

provide local telephone service over their networks today must use circuit switched technology. All of the existing commercially deployed primary telephone lines serviced by cable companies are implemented on circuit switched equipment.

The lack of commercially available IP telephony technology leaves cable operators with a dilemma. They can either deploy circuit switched telephony today, or wait for IP telephony in the future. This dilemma has contributed to the decision by cable operators to focus their efforts on services other than cable telephony.

The following sections discuss the reasons why commercially-deployable IP telephony is not currently available. The technical issues holding IP telephony back revolve around the availability of certified and thoroughly tested equipment supporting IP telephony and the underlying data networks IP telephony systems require. Additional issues affecting the deployment of IP telephony include the need to train staff and deploy hardware in the field.

Even when it becomes available, IP telephony may not be the panacea that some claim. The costs of operating an IP telephony system may not be significantly lower than those of circuit switched networks; this may influence the investment decisions of the MSOs considering telephony rollouts. Finally, IP telephony service is subject to the same pressures on revenue as circuit switched telephony described in the previous section.

1. Definition of IP Telephony

IP telephony is the digitization and packetization of voice signals such that they may be carried on a variety of underlying physical data networks. In addition, there are a number of ancillary functions that are necessary to support IP telephony, including signaling, switching, security, provisioning, billing and network management. In the context of this paper, IP telephony represents an alternative to circuit switched primary line voice technology that is implemented over high-speed, high quality of service, two-way active cable plant.

2. Status of IP Telephony Technology

The most promising IP telephony technology for cable operators is defined in CableLabs PacketCable specifications. According to CableLabs,

> the basic PacketCable architecture defines what is known as "softswitch" architecture for voice-over-IP. The core set of PacketCable specifications describe how to move the basic functions that are typically consolidated on a single, expensive Class 5 central office switch onto several general-purpose servers, which leads to a low-cost, highly flexible, scalable, distributed architecture.[39]

It is likely that PacketCable will be the technology of choice for MSOs wishing to offer IP-based primary line telephone services. To date, no equipment has been certified. However, CableLabs has announced plans to certify PacketCable equipment in 2002. Any certification must be followed by, or completed in concurrence with, lab and field trials of the equipment.

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[39] CableLabs, Packetcable Project Primer, http://www.packetcable.com/packetcableprimer.html, viewed March 14, 2002.

Packetcable telephony systems presume an underlying data network based on DOCSIS 1.1 cable modems.[40] Compared to DOCSIS 1.0, with 193 modems certified over a period of several years, DOCSIS 1.1 is in its infancy. There have been some problems with ". . . the stability of underlying DOCSIS 1.1 access networks, which provide the quality of service (QoS) capabilities, including bandwidth and latency guarantees, required to offer voice over IP."[41] These issues must be addressed before IP telephony can be offered commercially.

PacketCable and DOCSIS 1.1 represent the most likely technologies for the implementation of IP telephony over cable networks. Equipment built to these standards will undergo certification and testing programs in 2002, but will be available for initial commercial deployment in 2003, at the earliest. Progress is much slower than cable companies expected, even a few years ago.[42] Therefore, cable operators interested in using IP telephony as the foundation of their telephone service offering must wait.[43]

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[40] CableLabs, Press release, "CableLabs Certifies 7 more DOCSIS 1.1 Modems, Continuing Cable Data Advances," December 20, 2001.

[41] Kinetic Strategies, Inc., "Vendors Push Cable VoIP Integration," *Cable Datacom News*, December 1, 2001.

[42] This point is emphasized by a 1998 article in Cable Datacom News, which states, "AT&T plans to deploy cable telephony services in three phases. The company will quickly launch circuit switched cable telephony I several TCI markets. By late 1999, AT&T expects to start deploying its IP telephony platform to bypass ILECs. The final step is to link AT&T's local cable IP telephony networks with the company's national packet telecom network, which is now under development, to offer end-to-end IP voice services." "AT&T Outlines Cable Telephony Strategy Three Phase Plan Calls for Migration from Circuit Switched Deployments to Pure Packet Telephony," *Cable Datacom News*, August 1998.

[43] As is typical with any new technology, a number of cable operators are conducting trials of IP telephony equipment. Some of these trials use equipment that may eventually be certified by CableLabs. This does not change the conclusion regarding the timing of IP telephony deployments as a primary access line service.

3. IP Telephony Offers Minimal Operational Savings

Although IP telephony may offer certain advantages over circuit-switched telephony, it appears that from an operational perspective an IP telephony network will be about as costly and involved as circuit switched telephony. Both technologies require many of the same functions, such as installation, provisioning, order processing, network monitoring and management, long distance interconnection, E911 service, billing, and repair.[44] In addition, significant technical expertise is required to implement and operate either technology, so learning curves and staff training requirements are similar.

Even after thoroughly tested and proven IP telephony equipment does become available, cable operators may decide not to offer primary line telephone service. The costs associated with operating IP-based and circuit switched cable telephony systems are comparable and the same revenue pressure described previously for circuit switched cable telephony service will apply. The point is, even when IP telephony does arrive, it may not be the "silver bullet" that the cable industry had hoped for; it may represent no less financial risk to the cable operators than circuit switched telephony.

4. The Role of Circuit Switched Telephony

Today, circuit switched technology is the only viable alternative for cable operators seeking to offer primary line telephone service in direct competition

[44] Braden Presentation.

with an incumbent local exchange carrier. This fact is widely recognized throughout the industry, and by the FCC.[45]

However, since many operators such as Time Warner, Charter and others, including AT&T Broadband, have been waiting for IP telephony to become commercially available, it is unlikely that any significant investment in cable circuit switched telephony will be made in the immediate future.[46]

D. Cable Telephony as an Option for Businesses

Cable television systems do not have the capacity to serve large numbers of business customers requiring DS-1 and higher-speed services. The reason is that, while upgraded cable systems are built with substantial capacity, the bulk of the network was built for broadcast services. Thus even upgraded networks have much more downstream (from cable operator to subscriber) capacity than upstream (from subscriber to cable operator) capacity. Furthermore, cable systems are generally built to share bandwidth among a large number of subscribers, so the upstream capacity, on a per subscriber basis, tends to be limited. Finally, due to technical limitations of the network, the bandwidth efficiency, expressed as bits per second per Hertz of bandwidth, in the upstream path is considerably lower than in the downstream. This means that cable operators realize lower upstream data rates than downstream data rates, per unit

[45] *8th Annual Video Programming Report,* p.5.
[46] "The promise of IP telephony has a lot of operators sitting on the sidelines while the engineers at CableLabs work on certifying the first DOCSIS 1.1 equipment (modems and CMTSs) that is absolutely essential to any IP telephony implementation on cable's HFC networks." CED Magazine, "Cable telephony sending mixed signals," April 2001.

of spectrum. In sum, upstream bandwidth in a cable television network is at a premium.

Traditional private-line T-carrier circuits are dedicated to a single user and offer symmetrical capacity. Unfortunately, the cable network does not lend itself to the provision of this kind of service. Offering dedicated services of this nature would quickly exhaust the upstream capacity of even an upgraded cable network.

Dedicated circuits, like those discussed above, are much different than the broadband Internet access service now supported by many cable systems. Broadband Internet service supports relatively infrequent high-speed bursts of data to and from subscribers. Internet users typically transmit or receive data a small fraction of the time. Traditionally, the “bursty” nature of typical Internet transmissions allows cable capacity to be shared by a number of users, and no capacity is dedicated to any given user.

In addition to sharing bandwidth among many concurrent users, cable modem systems were developed under the presumption of asymmetrical data streams. Asymmetric systems work well for most Internet users since the average user consumes much more data than they transmit. An asymmetric system may even work well for a large business, but only for the provision of Internet service. In fact Time Warner offers RoadRunner Internet access to large businesses in a number of locations throughout the country, but it does not sell dedicated point-to-point carrier grade connections; presumably for the reasons discussed above.

Cable systems were for the most part built to serve residential and suburban areas. Even in those places where cable service is available in a central business district ("CBD"), it has historically been unsuitable for high-capacity business use because of its lack of reliability in comparison with telephone service. Cable television service is not critical to public safety and has not been subject to the availability requirements placed on tariffed telephone service by state regulators.

Upgraded cable networks may be suitable for the provision of Internet access to even large businesses, but the shared nature of the cable network, and its limited upstream bandwidth make it unsuitable for the provision of symmetric, dedicated, private-line services.[47]

E. Conclusion

Only a small number of residences and businesses actually have a local access option through their cable provider today. Where these options do exist the de facto technology is circuit switched cable telephony. While IP telephony holds promise for the future deployment of local telephone service over cable networks, the systems supporting this technology are in their infancy. As a result, commercially available IP telephony in the local exchange is not currently available.

[47] The development of IP telephony technology does not change this conclusion. While IP telephony provided over CATV networks may someday provide a viable alternative to circuit switched business telephone services, it will not support the kind of dedicated network facilities discussed in this section.

For all of the reasons discussed in this section, it is premature to make policy decisions on the presumption that telephony through cable systems will become a pervasive or effectively competitive offering.

VI. Mobile and Portable Wireless Technologies

There are several independent reasons why wireless technologies developed for cellular and personal communications services cannot be used to displace wireline telephone service to any significant extent. First, demand for mobile and portable wireless service continues to expand at a high rate, and existing and planned technologies cannot serve both this demand and any significant fraction of wireline demand. Section A demonstrates this fact with a detailed technical capacity analysis. Numerous current news articles discussing deteriorating service quality for mobile and portable wireless subscribers are further evidence of this problem.

A second problem is that wireless suffers from coverage and quality problems. Wireless coverage is marginal or inadequate inside many buildings, including offices as well as homes. There are as well many outdoor coverage “holes,” even in urban areas, in which signal levels are barely adequate. Indoor coverage in such areas is essentially useless. The only way of improving coverage involves adding significant numbers of cell sites in heavily populated areas, a process which is enormously expensive and which often faces virulent community opposition.

Digital wireless voice quality is lower than corresponding wireline voice quality, because wireless systems require low-bit-rate voice encoding techniques to use the assigned spectrum efficiently. Such coding techniques do not provide voice quality on a par with that offered by the higher-bit-rate techniques used in the wireline network.

Finally, current and next-generation digital cellular and PCS technologies support only relatively low data rates that are inadequate for web browsing and other Internet related applications. This will inhibit some customers from giving up their wireline for wireless service.

Various fixed wireless technologies, which compete directly with the CLECs building fiber rings, are discussed in Section VII.

A. Wireless and Wireline Demand

Average per-subscriber wireline telephone use, expressed either as minutes per use per month or in telephone traffic terms, has historically been much greater than wireless usage. For purposes of network capacity analysis, it is most useful to consider wireless and wireline usage in traffic engineering terms. A common assumption has been that wireless subscribers generate one-fifth of the busy-hour traffic that the typical wireline subscriber generates in the busy hour. Appendix A demonstrates that, although this ratio has decreased somewhat, a wireline subscriber still generates about three times the busy-hour traffic of a wireless subscriber. Reductions in the effective price per minute of wireless service, coupled with widely-available bulk calling plans, have contributed to this increase in wireless usage.

Nonetheless, the average wireline subscriber still generates much more local traffic than the wireless user, and wireline per-subscriber usage is growing as well.[48] The net result is that, in terms of traffic alone, a wireline user requires three times the network capacity resource of a wireless subscriber.

B. Wireless Network Capacity and Coverage

Wireless service quality today is notoriously poor in many markets, a fact that has been widely reported in the general press.[49] Wireless carriers are to a large degree victims of their own marketing success and have had much difficulty in providing facilities to meet increasing demand.

1. Technical Limitations and Business Considerations

A wireless network's service quality depends on two critical factors: there must be sufficient resources (radios) equipped in each cell site to serve subscriber demand in that cell, and there must be a sufficient number of cell sites located properly to ensure adequate signal strength, or "radio coverage," within the service area, both outdoors and within buildings.

A cell site represents a significant investment, often exceeding a million dollars for a site with large towers. Due to the limited coverage areas of cells in built-up areas, wireless carriers usually cannot rely on conventional commercial transmitter sites, such as those located on geographical prominences in a metropolitan area, for a significant amount of their coverage. That is, many cells are required so those on geographical prominences can only provide partial coverage. They must also lease or purchase many other sites around a

[48] See, *e.g.*, FCC, "Trends in Telephone Service," Industry Analysis Division, Common Carrier Bureau, August 2001 ("Trends in Telephone Service"), table 11.2, p. 11-4.
[49] See, *e.g.*, Jeffrey Selingo, "Complaints skyrocket along with cellphone use," *The New York Times,* reprinted in *The Denver Post,* February 18, 2002, p. 1E.

coverage area, construct masts for antennas that may be anywhere from a few tens of feet to well over a hundred feet in height, construct a hut or small building to contain radio and backhaul transmission equipment, buy and install this equipment, and arrange for backhaul transport to connect the cell site to the switched network via a wireless switching center.

This process also involves obtaining local approval for the site itself, which can be very difficult and time consuming. Municipalities quite often object to the presence of such facilities for esthetic reasons, and, more recently, out of concern for perceived biological hazards caused by the non-ionizing radiation generated by the cell-site radio equipment.[50]

Cell sites cannot contain arbitrarily large numbers of radios, both for engineering reasons and because the carrier has a limited amount of spectrum available under its license to serve subscribers. Practical technical limitations prevent cell sites from being configured with enough radios to exhaust the carrier's assigned spectrum. Many cell sites, particularly in urban areas, are thus out of capacity and simply do not have the ability to serve additional mobile and portable users, certainly not the high number of additional users that would result if wireline users began switching to wireless in substantial numbers. Appendix B discusses these capacity limitations in greater detail.

It makes no sense from a business standpoint for wireless carriers to attempt to displace wireline telephone service. As is discussed in Appendix A, wireline subscribers served by wireless networks require considerably more of the network resources per subscriber than do mobile/portable wireless users, and wireline per-subscriber traffic continues to increase.

As discussed above, and in Appendix A, the traffic generated by a wireline subscriber is about three times that of a mobile/portable wireless user. One wireline subscriber who shifts to wireless thus displaces an average of three mobile/portable subscribers. According to the Cellular Telecommunications and Internet Association ("CTIA"), the average local wireless service bill as of June 2001, was $45.56. Assuming fixed capacity in the wireless system, the opportunity cost to the wireless carrier is significant. The FCC reports that, in 2000, the average per-subscriber monthly telecommunications expenditure was $35.[51] Under the assumption that this value is increasing at the rate of one dollar per month annually, the corresponding value for June, 2001, is about $36.50. The opportunity cost to the carrier per fixed wireless subscriber is therefore about $100 per month. [52]

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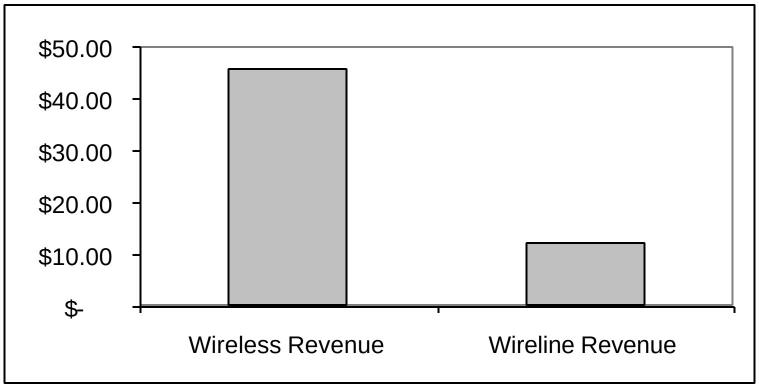
[50] Whether the hazards are real or imagined remain to be proved. The perception, however, is quite real.
[51] Trends in Telephone Service,, Table 3.2, p. 3-4. This value also presumably includes intra-LATA toll charges, as it represents average monthly payments made to ILECs and CLECs. We will, however, conservatively assume that intra-LATA charges are not included.
[52] There will of course be cells with excess capacity, particularly in low density areas. In these cases the opportunity cost will be much lower. The ability to exploit such capacity is likely limited to less densely populated areas.

Figure VI.1
Wireless Opportunity Cost



Wireless carriers are now striving to find ways of better serving their current demand and are finding few alternatives, much less alternatives that would allow them to expand significantly. As one analyst has noted:

> There is little new wireless spectrum set to become available in the near future. The outline set by former President Clinton has fallen by the wayside, and spectrum in the 1710-1850 MHz and 2500-2690 MHz bands seems farther away from being available now than it was a year ago. The PCS reauction (Nextwave) issue has yet to be resolved, and the 700 MHz spectrum scheduled to be auctioned this year has a variety of flaws, in our view.[53]

Once suitable spectrum is reallocated, it is a certainty that the spectrum licenses themselves will be very expensive for wireless carriers.

Beyond the cost of the new licenses, enormous investments will be required for new infrastructure and subscriber equipment compatible with the new frequencies. It is not likely that wireless carriers would even attempt to attract large numbers of wireline subscribers in the face of the financial pressures

[53] Kevin Roe, *et al.*, "US Wireless Telecom 2002: The Odds Are Better; Place Your Bets*,"*, ABN-AMRO, February 7, 2002, p. 12.

that inevitably will underlie the introduction of third generation ("3G") technology in new spectrum.[54]

The opportunity cost concern is also the probable reason why papers and articles discussing the need for additional spectrum to accommodate expanded 3G system capacity do not address significant degrees of displacement of wireline telephone service by wireless systems. The President's Council of Economic Advisers ("CEA"), for example, published a report in 2000 on the economic benefits of 3G wireless technology.[55] This report contains no mention of such displacement of service. It does include a revenue analysis with revenue expressed per megahertz of allocated bandwidth and uses that value to estimate the service revenues that would flow from an increased spectrum allocation. The CEA's analysis and conclusions would be much less sanguine if significant wireline displacement were anticipated and the corresponding opportunity cost factored into the study.

2. Coverage and Quality issues

A wireless subscriber may receive wireless service in a home or office by just employing his or her handheld wireless phone or by using a specialized wireless device, such as those made by Telular Corporation, which is specifically designed for fixed use.[56]

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[54] See Tim Kridel, "3G: Accidents Will Happen," *The Net Economy*, June 25, 2001, for a discussion of this and related issues.

[55] The Council of Economic Advisers, "The Economic Impact of Third-Generation Wireless Technology," October, 2000.

[56] Telular Corporation, Dial Tone and Data for the Wireless World, Products, http://www.telular.com/products, viewed March 14, 2002.

In the first case, in which subscribers simply use their portable wireless phones as wireline replacements, indoor radio coverage is obviously critical. It is, however, all too often either marginal or inadequate, even in urban and suburban areas. There has been considerable press coverage of the inadequacies of wireless service, including poor signal strength in cities.[57] Furthermore, even if a usable signal exists in a certain location in a house or office building, other locations, especially basements and lower floors and areas away from windows, will likely not exhibit adequate signal strength, so users must stand or sit in very specific locations in order to maintain acceptable voice quality (or worse, to maintain the wireless connection). This effect is well-known to anyone who has attempted to use a wireless phone indoors.[58]

Even outdoor coverage is often spotty in urban areas, particularly in densely-populated central business districts among tall buildings. Coverage is better on the upper floors of tall buildings than it is in lower floors and at street level, and signal strengths further deteriorate progressively as they travel farther into building interiors.[59] Again, any wireless subscriber with a handheld wireless phone is well-acquainted with the common need to wander around the typical office building in an attempt to find a location with sufficient radio signal strength to conduct a voice conversation of adequate quality.

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[57] See, Selingo, *supra*. note 49.
[58] The predominant means of signal propagation for wireless systems in built-up areas is scattering and not line-of-sight transmission. The communications “channel” in this case is a variety of paths between the transmitter and receiver, each of which typically consists of a series of reflections from buildings and other large objects. The individual paths are independently corrupted, and the received signal strength can only be predicted using statistical methods.
[59] Theodore S. Rappaport, *Wireless Communications Principles and Practice,* Second Edition, Prentice-Hall PTR, Upper Saddle River, NJ 2002, p 166.

Despite these problems, it is clear that there is, and will continue to be, some small fraction of subscribers who use wireless phones exclusively. A recent trade news article indicates that 1.7 percent of U.S. households use wireless phones in place of landline service.[60] One can easily imagine that members of certain classes of subscriber such as young singles living alone might rely exclusively on their wireless phones for all their telephone service. (and whose home wireline service usage is likely considerably lower than, say, that of a typical family). This presupposes, though, that these subscribers live in areas in which wireless coverage is adequate even inside their homes. As was discussed earlier, wireless coverage continues to be substandard even in many urban and suburban areas, and it is difficult and expensive for carriers to improve it.

A few wireless carriers encourage potential subscribers to use their wireless service in place of wireline telephone service. Cricket Communications, for example, offers a prepaid, flat rate, local-only wireless service in a number of markets, and Cricket television commercials (directed primarily at the young singles market noted above) exhort prospective subscribers to use the Cricket service as their primary telephone service at home. Cricket's approach is to convince potential customers that their wireless service can be affordable, particularly if the subscriber can do away with his or her existing wireline telephone service. Cricket's service is very basic and does not include bundled

[60] Cellular Telecommunications and Internet Association web site, "Study Finds More Consumers Pulling the Plug on Fixed-Line Phones," January 30, 2002, http://www.wow-com.com/news/daily-news/pub_view.cfm.

vertical features or toll service, although these are available for additional charges.

In the second case, a subscriber may use a “fixed” wireless telephone with an integrated antenna. Such a phone operates in an identical fashion to a wireline telephone (it generates dial tone, the user dials using a normal keypad, etc.), and the phone contains circuitry to interface the common telephone functions with the integrated wireless components. Another option is a fixed wireless terminal that has a standard RJ-11 telephone jack and allows the subscriber to connect a common wireline telephone or fax machine. Either of these devices can be used with an external antenna mounted directly on the device and which likely offers slightly improved performance over the antenna integrated into typical handheld wireless phones. These units also can be used with higher-gain antennas mounted outdoors and connected to the unit via coaxial cable.

The use of an external antenna can improve the signal delivered to the wireless phone. These antennas typically have higher gain than those on portable units (meaning they intercept more of the power transmitted by the wireless cell-site transmitter and are thus “directional”) and also avoid the building penetration problem. They also require mounting in a suitable location, possibly on a mast, and the connection between the antenna and the fixed wireless phone must be protected from lightning strikes. Deployment of external antennas invariably requires professional installation. Because such antennas are directional, they must be pointed in the correct direction and suitably attached to the building structure. This increases the per-subscriber investment on the part of the carrier, thus increasing the opportunity cost.

There are at least two recent and pertinent examples of failed attempts to replace wireline service with wireless service using dedicated networks. AT&T, over the past several years (and before it spun off its wireless operation), spent heavily ($1.3 billion) on Project Angel, a new wireless technology expressly designed for fixed voice and data service.[61] AT&T's motivation was the development of a wireless service to complement its cable telephony service in order to expand its options for serving end users directly, thereby avoiding access charges and the costs and aggravation of attempting to lease loops from ILECs. After several years of development, AT&T finally introduced its fixed wireless service in Fort Worth in 2000, with plans to expand to 1.5 million subscribers by the end of 2000 and 10 million by the end of the following year.[62] They only made it to about 47,000 total subscribers.

In a clear statement of its lack of interest in the fixed market, AT&T Wireless, once it was spun off by its parent in July, 2001, wasted little time in unloading the Project Angel technology, associated staff, and the few subscribers actually served by the fixed system. It sold the Project Angel assets to Netro Corporation for $16 million in cash plus stock. Netro has equipped a number of fixed wireless networks internationally, most typically in areas such as Eastern

[61] AT&T Wireless News Release, January 29, 2002. AT&T goes on to say in this release that it "intended to exit the fixed wireless business."
[62] John Borland, CNET News, March 22, 2000.

Europe that do not have extensive and well-maintained wireline communications networks.[63]

Ionica is another prominent example of a company that based its business plan on its hopes of displacing wireline telephone subscribers with a fixed wireless service. The UK-based company developed a sophisticated fixed wireless technology to compete with British Telecom for fixed voice and data services. Its business plan was apparently based on a modest penetration of the UK market of seven percent (about 2.8 million subscribers), but the company failed in 1998 with a total subscribership of about 62,000. Analysts blamed technical and financial problems for the failure.[64]

C. Wireless Data Service for Wireline Replacement

An increasing share of landline usage is for data applications. However, new mobile wireless data services are not a significant threat to displace this landline usage. Second-generation wireless systems can support only modest data rates, typically about 10 kbps. The improved radio transmission technologies classified as 2.5G systems can support rates of several tens of kilobits per second per subscriber (for 2.5G code division multiple access, or "CDMA," about 64 kbps per subscriber), which are comparable to the rates achievable with a current voiceband dialup modem on a wireline connection.

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[63] http://www.netro-corp.com/netroframelayoutnnpc.html

[64] Chiyo Robertson, "Ionica collapses as white knight bails out," October 30,2000, at http://news.zdnet.co.uk, and "Ionica lays off 600 employees," November 2, 1998, at http://news.bbc.co.uk.

These increased per-subscriber data rates, however, come at the expense of dedicated additional radio resources to a single user.[65]

Third-generation wireless systems will offer data rates exceeding 144 kbps, even for high-mobility traffic. This value, in fact, is a threshold number often used to define, at least in part, a 3G technology. Corresponding rates for pedestrian and "indoor" users, such as a person in an airport lounge with a radio modem connected to a laptop computer, range up to 2.4 Mbps or so.

What is often misunderstood about these rates is that they represent an overall radio channel data rate, and the channel is shared among many subscribers using packet radio techniques. The average per-subscriber rates are much lower, probably between 50 kbps and 100 kbps, depending on the number of subscribers and their usage characteristics.

This fact, coupled with the radio coverage and capacity issues discussed earlier, suggests that wireless systems, even using the latest available technology, are unsuitable for supporting a large number of displaced wireline data users. Displacement of significant numbers of asymmetric DSL ("ADSL") subscribers is very unlikely, both from a capacity and service quality point of view. Furthermore, such business-oriented wirelines services as high-bit rate DSL ("HDSL") and g.shdsl cannot be supported in any quantity by wireless

[65] Even higher per-subscriber rates can be made available with 2.5G technology, but this inevitably requires dedicating extra radio capacity to a single user, thus displacing several voice channels. With 2.5G GSM techniques, for example, a single user effective rate of about 384 kbps can be achieved, but at the cost of dedicating eight time slots, or voice channels, to that user. Similar reassignment of radio capacity is required to obtain 2.5G CDMA per-subscriber rates of about 64 kbps.

systems because of the requirement for dedicated capacity in the radio system and because of quality of service concerns.[66]

D. Wireless Industry Structure

The current structure of the mobile wireless industry provides another basis for skepticism that this platform will challenge the ILEC monopoly. Many of the largest wireless carriers are owned by ILECs. These firms do not have an incentive to engineer their systems and market their services to provide a direct substitute for landline networks. The control over the wireless industry by the ILECs may grow as the FCC eliminates its wireless spectrum cap.

E. Conclusion

While wireless provides an adequate substitute for ILEC fixed narrowband services for a limited subset of consumers, this platform is not in a position to limit the exercise of ILEC market power. There is insufficient capacity for wireless services to discipline ILEC pricing. Quality is lower along a number of dimensions. Wireless does not support Internet access even at the rates available from narrowband connections. Finally, the wireless industry is increasingly controlled by ILECs.

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[66] Also known as G.991.2, g.shdsl, is an international standard for symmetric DSL ("SDSL") developed by the International Telecommunications Union ("ITU"). G.shdsl specifies a technique for sending and receiving high-speed symmetrical data streams over a single pair of copper wires at rates between 192 kbps and 2.31 Mbps.

VII. CLEC Fiber Ring and Fixed Wireless Competition

Fiber ring technology provided by CLECs is the oldest local exchange competition platform.[67] These CLECs install fiber optic lines in urban areas using a ring architecture. They are then able to provide customers in certain buildings near the rings with a variety of services from switched local telephony to DS-3s. Certain fixed wireless operators have attempted to compete along with the fiber carriers by providing high-capacity links primarily in business districts. Some background and history of the fiber ring business is provided in Section A. Section B describes the steps needed for CLEC fiber carriers to expand. Section C discusses the fixed wireless CLECs. The implications of recent CLEC financial problems are discussed in Section D. Section E provides the conclusions.

A. The CLEC Business

Competitive Access Providers ("CAPs") were, in essence, the first CLECs. CAPs provided point-to-point telecommunications services over fiber rings in major markets starting in the years following the breakup of AT&T. Initially CAPs were created to take advantage of an opportunity to provide high capacity (fractional T1 and higher rate) services among large corporate customer locations and access to IXC POPs. They offered these services at rates that were lower than equivalent special access service tariffs offered by the ILECs, but still offered the CLECs positive margins. CAPs also provided redundant connectivity to create highly fault-tolerant customer service networks.

Even prior to the 1996 Act, CAPs had installed end office switches in larger markets and were providing switched and dedicated interexchange access services to large business customers. In jurisdictions where it was allowed, the CAPs also provided switched local services. Following the passage of the Act, many CAPs became CLECs. They applied for state certification to become local exchange carriers and installed switches in almost all markets where they operated fiber facilities. The new CLECs negotiated interconnection agreements with ILECs and expanded their fiber rings to interconnect with multiple ILEC wire centers (and tandems) in core business districts. Access to ILEC wire centers facilitated a strategy of swifter market entry using unbundled loops to connect to customers pending fiber ring expansion and/or negotiating and constructing building access.

CLECs that started out as CAPs have evolved beyond providing dial tone and dedicated circuits. Many have acquired or started ISP operations, and are also providing web hosting and web site development services. Most resell long distance service and many of them have constructed their own intercity fiber networks. These facilities-based CLECs continue to focus almost exclusively on business customers, although a few carriers, such as RCN, have targeted multi-unit residential dwellings in major urban areas. The recent CLEC financial difficulties are discusses in Section C below.

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[67] The potential for new types of CLECs that would use fixed wireless technology was identified in the late 1980's. However, these alternative CLECs have achieved de minimus stature as competitors to the ILECs, for reasons discussed in Section VII.

B. Potential Fiber Ring Competition

The CLEC fiber ring platforms consist of the fiber optic transmission medium and associated structure, appropriate multiplexing nodes from which spurs can emanate towards individual customer premises, switches that establish connections between originating and terminating customers, and an interoffice network to connect the switches to each other.

Typical CLEC facilities networks are illustrated in Figure VII.1. The bulk of the investment is in the core urban areas or CBDs of larger cities. As shown by the dotted lines in the Figure, the CLEC networks may reach many buildings within a CBD, but are unlikely to reach all of them. The CLEC networks may extend to one or more outlying business districts, but are unlikely to reach all of them. CLEC networks will not serve large portions of the metropolitan area. For example, WorldCom reports that even in the wire centers where it has fiber facilities (or has contracts with other CLECs who have built facilities), the vast majority of its high-capacity customers are in buildings that are reached only by ILEC facilities.[68] There will, of course, be significant numbers of wire centers in the surrounding metropolitan area where no CLEC has facilities, but where nevertheless high-capacity customers will be located.

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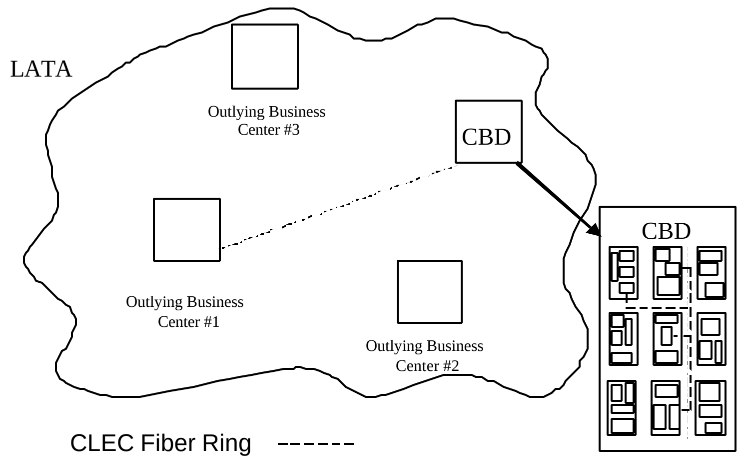
[68] In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, CC Docket No. 01-338, Declaration of Peter H. Reynolds on Behalf of WorldCom, Inc. ("Reynolds confidential ex parte") (filed under protective order, April 4, 2002).

Figure VII.1
CLEC Presence



The CLEC fiber platform will never be able to challenge the ubiquity of the ILEC network. This can be demonstrated in two ways. First, the process of expanding these networks to serve new buildings or new areas is described. Second, the source of ILEC economies of scale is described and the magnitude of those economies is measured. Finally, in Section 3, the extent of fiber ring capacity measured by buildings reached is discussed.

1. CLEC Entry and Expansion

The fiber ring platform cannot provide significant additional competition to the ILECs because it is uneconomic to serve customers unless density is high. This can be illustrated by describing the steps necessary to extend fiber ring network platforms to serve new customers. To add a location to its network, the following steps are necessary:

1) A spur must be constructed from the ring to the customer location. Building a spur in an urban area can cost between $72-$105 per foot.[69] If the customer is a block away (about 500 feet) this will cost between $36,000 and $52,500. If the customer requires route redundancy, the costs rise accordingly. If the customer is located several blocks from the ring, it generally makes sense to serve the customer only if there is justification to extend the ring itself, which is a multimillion dollar project.[70] The costs of constructing network outside of the CBD may be smaller per foot, but the distance required to reach each additional customer is generally greater.
2) The customer's building must be entered and connections made to the appropriate terminal equipment, located in an appropriately conditioned space, which provides circuits of the bandwidth required by the customers in the building. Building access requires negotiations with the building owner. In most cases, building owners require compensation for the right to enter the building, the floor space required to install circuit equipment within the building and the use of riser conduit.
3) Building-related investment is required for preparing space, arranging power connections, installing equipment bays, and routing cables. There will be recurring costs for leasing the space and for power that may be supplied by the building owner. The DS-1 circuit equipment investment runs

[69] *In the Matter of Federal State Board on Universal Service*, CC Docket No. 96-45, Forward Looking Mechanism for High-Cost Support for Non-Rural LECs, CC Docket No. 96-45, Further Notice of Proposed Rulemaking, FCC Document No. 99-120, released May 28, 1999 ("*FNPRM*").

approximately $5,000 per DS-1. The investment for DS-3 circuit equipment may be in excess of $30,000.[71] Depending on a range of variables, including the amount of space required, the extent of the physical preparation, prevailing building lease rates, and power costs, the total investment in building space, including initial investment and the NPV of recurring costs, could exceed $100,000.

These costs are not inconsequential. For example, if there is only demand for a small number of voice grade or T1 lines in a given building, or the building is located too far from the CLEC fiber ring, it may not be economical to build the facilities to serve customers in that building at all. The per-line cost of the terminal equipment, the ring extension, the building costs, or any combination of these, may be too high. If one assumes annual revenue per DS-1 of approximately $6,000, it will obviously be uneconomic to serve customers in buildings where there is limited DS-1 demand. According to WorldCom, a CLEC will not even consider expanding its network to a building unless the revenue equivalent of multiple DS-3s can be generated.[72] This means that even in densely populated urban areas a significant number of customers do not now have, and will not in the near future have, alternatives to the ILEC.

Figure VII.2 shows the relationship between revenue, cost and density for the fiber ring platform. It is obvious that rings will not be built to serve medium

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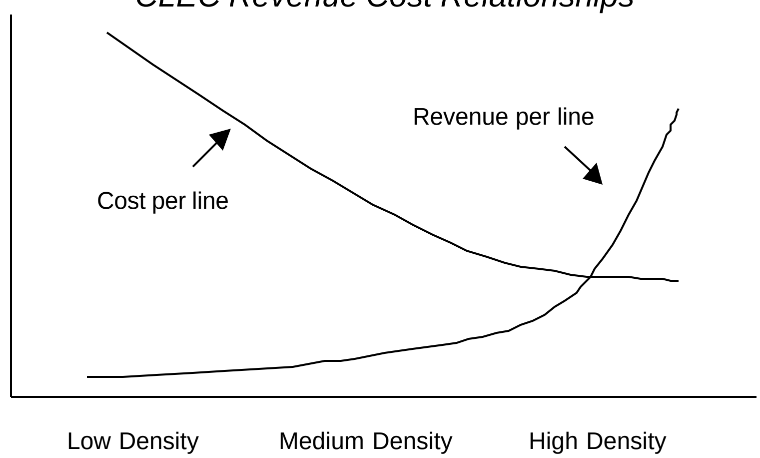
[70] See Declaration of Edwin A. Fleming, *In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, June 11, 2001 ("Fleming Declaration") para. 10.
[71] These costs are consistent with those used in the HAI Cost Proxy Model.
[72] Fleming Declaration, para. 10.

density business or residential areas. The revenue side of the expansion equation reinforces the difficulty of serving less dense areas with this technology. Revenue per square mile obviously falls as density falls (assuming businesses are concentrated in high density areas). Revenue for business customers is much higher because local services are provided at business rates and business customers may need dedicated circuits and data services.[73]

Figure VII.2
CLEC Revenue Cost Relationships



This analysis also applies when ILEC wire centers are considered as the locations to which CLECs might want to extend their networks. CLECs obviously have connected their own fiber to many ILEC wire centers. However, the cost of adding additional ILEC wire centers to their networks is significant. CLECs connect to a limited number of ILEC central offices.[74] WorldCom estimates that the cost of extending its local network to an additional ILEC wire center is at least one million dollars, even if the wire center is close to WorldCom's network. Costs

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[73] Moreover, the necessarily limited geographic scope of CLEC offerings makes mass marketing of service difficult. If CLECs have loop facilities in geographically limited areas within a marketing

rise if the wire center is several miles from the WorldCom network.[75] Given these large costs, it is simply not viable for CLECs to build to all ILEC wire centers. The route must be relatively short and the traffic density must be relatively high. For example, WorldCom reports that only approximately five percent of the ILEC central offices generate sufficient traffic to justify construction of transport facilities to reach them.[76]

These high costs of fiber ring expansion help to explain why CLECs must rely on ILEC provided facilities to serve their customers even in dense urban areas. While it may be true that the majority of high-capacity lines are in the areas served by CLECs, there will be significant demand in other areas as well.

The "urban sprawl" common in many cities results in businesses being located throughout a large urban area. This will include branches of businesses whose main location is in the CBD or other areas of concentrated demand where the CLECs do own loop facilities. For example, a large bank or retail operation will have outlets throughout the city. In order to provide local service or a local data network to these customers as a "full service" provider, a CLEC must be able to provide them a citywide network. A CLEC can do so economically only if it can serve the locations outside the CBD by purchasing UNEs from the ILEC. Without the ability to do so, the CLEC ability to compete will be impaired.

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region, it is expensive to use mass media to advertise.

[74] Reynolds confidential ex parte" para. 13.

[75] Fleming Declaration, para. 8.

[76] Reynolds confidential ex parte, para. 12.

2. ILEC Economies of Scale

The ILECs have already constructed ubiquitous networks that are being used to provide both narrowband and high-capacity services. As a result, the ILECs enjoy significant economies of scale and scope. Foremost among the barriers to entry and expansion that must be overcome by the CLECs are the significant sunk costs that they must incur to provide service that are described above.

Simply put, construction of competitive CLEC loop facilities in less dense geographic portions of cities is not viable. Economies of scale in local networks suggest that for the foreseeable future the ILECs will be the sole supplier of both low and high-capacity services in many geographic areas, including geographic areas that contain high-capacity customer locations.

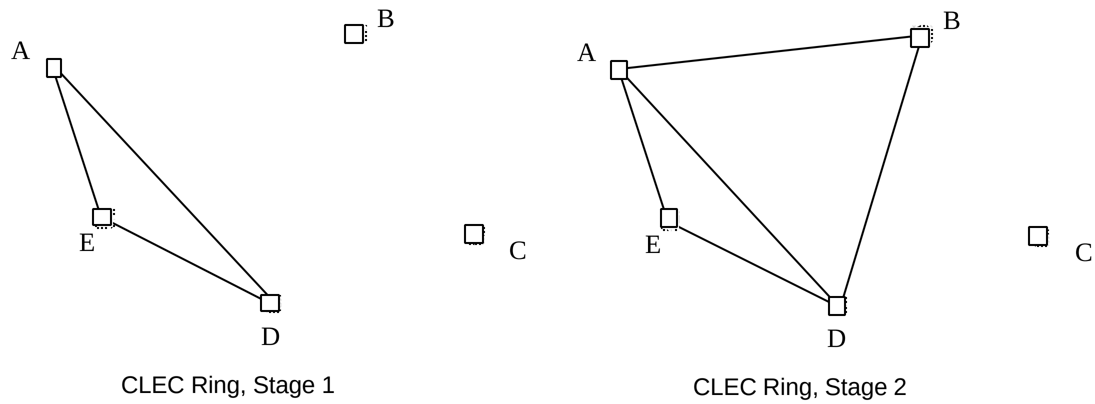
The source of these economies is easy to explain. The basic telephone company infrastructure consisting of poles, conduit and underground plant that support both voice grade and high-capacity loops is, within a large range, invariant to the number of circuits provided. Investment in these infrastructure items accounts for a high proportion of the total cost of the network. For example, in the HAI Cost Proxy Model, infrastructure (trenching, poles, conduit, and manholes) typically accounts for more than a third of total loop investment. Essentially, a CLEC must make all of these sunk investments to serve the first customer.

High capacity transport is also subject to significant economies of scale due to the need to make large sunk investments in infrastructure. Moreover, the

ILEC has the advantage of being able, in many cases, to share interoffice transport and loop feeder facilities. The ILEC transport networks carry substantial traffic, all of which produces revenue to defray the fixed costs of construction. CLECs will only be able to justify construction of such facilities on the most highly trafficked routes. Moreover, the ILECs are able to avoid transporting traffic that originates and terminates in the same office. The CLEC will have many fewer "offices;" therefore, it must transport a higher portion of its traffic.

Finally, the ubiquity of the ILEC networks allows for construction of a more efficient transport network. As Figure VII.3 shows, a CLEC wishing to expand its transport network from three to four nodes will have to construct two links to the fourth node to ensure path redundancy. But having done so, one of the links connecting the existing three nodes becomes superfluous. The ILEC do not have this problem because given their existing customer base, with established traffic patterns, they are in a better position to construct the efficient sized plant and network to serve their customers. The CLECs, on the other hand, face a great deal of uncertainty with respect to the quantity and geographic distribution of demand.

Figure VII.3
Transport Economies



Dr. Mark T. Bryant quantified the economies inherent in providing local services in a study presented in the UNE Remand Proceeding.[77] Dr. Bryant used the HAI model to estimate the costs per line of serving customers with a ubiquitous network when the serving carrier serves only a fraction of the market. Dr. Bryant found that in New York, "in dollar terms, the CLEC cost disadvantage ranges from $2,300 per line per month in the most rural areas, to $43 per line per month in the most dense areas at the five percent penetration level."[78] Similar results were obtained for transport costs, with the cost disadvantage higher for low competitive penetration, but disappearing more rapidly as market share increased.

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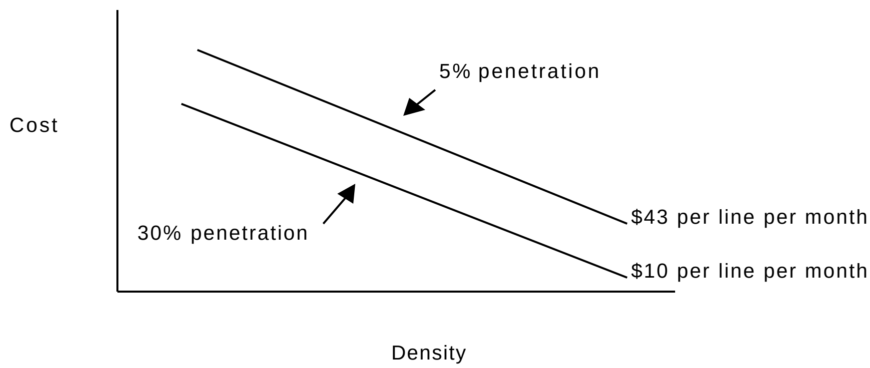
[77] *In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, CC Docket 96-98*, Comments of MCI WorldCom, Tab 3, Declaration. of Mark T. Bryant, May 26, 1999 ("Bryant Declaration"), paras. 2-20 (describing the economies of scale to which all loop, transport and switching unbundled network elements are subject).
[78] *Ibid*., para 28.

Figure VII.4
CLEC Loop Cost Disadvantage



This, of course, explains why CLECs have chosen to concentrate their investment where telecommunications demand is most dense – the central business districts and some outlying business centers within large cities. Only in these areas are there a sufficient number of potential customers for loop services, including high-capacity loops, to justify the sunk costs of building the necessary infrastructure to serve them.

C. CLECs Deploying Broadband Fixed Wireless Technology

A number of CLECs have attempted to compete using fixed wireless technology. Service providers using the digital electronic message service ("DEMS") and local multipoint distribution services ("LMDS") spectrum are reviewed here. In theory, these wireless systems avoid some of the expansion problems faced by fiber rings. However, this technology suffers from several independent limitations. These limitations help to explain why the fixed wireless market share discussed in Section IV above is so small.

Microwave systems operating at frequencies of 18 GHz and higher are very susceptible to fading caused by rain, and the severity of the fading increases with increased operating frequency. The overall effect of the fading is to reduce the effective operating range of the system, so that such microwave systems generally are not usable at ranges of more than a couple of miles if high availability is to be maintained.

Even with reduced range, these systems are still liable to endure rain fades. Reducing the range does decrease the likelihood of such fades, but they still may occur, particularly in areas prone to occasional high-rainfall-rate storms. As a result, businesses are often wary of such microwave service for critical applications (which arguably include any requirement for high-speed connections) and may be attracted to it only as a backup measure for more reliable service.

Microwave systems also require suitable locations on buildings for mounting antennas. Rooftop access can be expensive and difficult to negotiate; particularly since the need to locate cellular and PCS antennas on buildings in urban areas has made roof space especially valuable to building owners. Some microwave systems are designed to operate through window glass, so that a microwave terminal can be placed in an office and pointed at the other terminal forming the link. In order for this arrangement to work, however, there must be an office window in microwave line-of-sight of the remote terminal, and the office must be available to the customer. Even if acceptable building roof space is available, it can be difficult to establish line-of-sight paths to potential customers in a variety of locations. Existing estimates suggest that only around 60 percent of potential customer locations have suitable line-of-sight paths available to DEMS and LMDS hub sites.[79]

Point-to-point microwave systems operating in these bands and at even higher frequencies are thus unlikely in the near term to offer serious competition to cable-based broadband transmission systems operated by ILECs. Companies such as Teligent (DEMS) and Winstar (LMDS), are, as of this writing, in bankruptcy. Teligent is selling off its assets.[80] Winstar's new owner reports that it "gets no more than 1% of telecom spending in the buildings it serves."[81]

Other wireless approaches have been discussed. For example, free-space optical systems for high-capacity digital communications have been available for decades, but they generally apply to specialized needs and none has yet been an unqualified commercial success. Multichannel multipoint distribution service ("MMDS")/ instructional television fixed service ("ITFS"), and Industrial, Scientific, and Medical ("ISM") are being used primarily for broadband Internet applications and so are discussed in Section VIII.

D. The Implications of the CLEC Meltdown

Many of the CLECs that entered local markets after passage of the 1996 now find themselves in severe financial distress. Dozens of CLECs have

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[79] Ken Monro, "The Promise of the U-NII Bands – Making Sense of the Wireless WAN Confusion*," Broadband Wireless Online,* Vol. 2, No. 09, October, 2001.

[80] See Venture Asset Group to Manage Sale of Teligent Central Offices, January 24, 2002 Press Release, viewed at http://biz.yahoo.com/prnews/020124/sfth009_1.html. Winstar's assets have been purchased by IDT.

[81] Reported in Neil Weinberg and Michael Maiello, "Malone Clone," Forbes, April 15, 2002, p. 82.

declared bankruptcy and many others have reduced their planned investments in competitive networks.

There are numerous possible explanations for these events. Some competitors have blamed the recent downturn in their prospects on the lack of cooperation from the incumbent monopolists.[82] In a paper on behalf of USTA, Robert W. Crandall provides an alternative hypothesis. He argues ". . . that a company's choice of business strategy has been the most important determinant of its success or downfall."[83] The implication is that some competitors have adopted "winning" strategies. Dr. Crandall believes these "winners" will bring more competition to the market.

If Dr. Crandall's hypothesis is accepted, then policymakers need not worry about the current round of business failures. They can be confident that the stage has been set for market developments to bring competitive alternatives to consumers, as the Act intended, so long as the current regulatory environment remains unchanged. Although individual competitors may be falling by the wayside, the competitive process may still be healthy.

Dr. Crandall's hypothesis is not correct. The firms he studied in June 2001 to demonstrate the viability of facilities competition are now in serious financial trouble. Even more problematic is the fact that successful implementation of the CLEC strategies that he endorses will still leave most consumers without competitive alternatives.

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[82] See Shawn Young, "Covad, One of Last DSL Competitors, Blames Troubles on Bell Tactics," The Wall Street Journal, August 9, 2001, p. B1.

Dr. Crandall claims that competitors must build loop facilities to be successful. However, as described above, the CLEC business model simply will not result in the construction of loop facilities to serve residential and small business markets. As discussed in this Report, the potential competitive alternatives for these sectors are UNEs, resale, cable telephony, and wireless.

Even Dr. Crandall admits that cable telephony has achieved only modest market penetration. As discussed elsewhere in this Report, wireless and Internet voice have a set of their own problems to overcome. It appears that successful implementation of UNE and resale competition is required if the vast majority of consumers are to have a choice of carriers. Dr. Crandall's own case studies and econometric analysis demonstrate that these strategies are not working in the current market and regulatory environment. Therefore, a regulatory response is required.

1. The Telecom Collapse

One possible interpretation of the collapse is that it is due to a classic emerging industry "shakeout." There is no question that the CLEC business was due for such a shakeout. Such shakeouts are a normal part of the competitive process in emerging markets. Entrants adopt alternative strategies and the ones who both adopt the correct strategy and are well-managed succeed. Others go bankrupt or are acquired.

The shakeout theory is consistent with Dr. Crandall's argument that mismanagement or normal competitive activity is responsible for the demise of

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[83] Robert W. Crandall, "An Assessment of the Competitive Local Exchange Carriers Five Years

competitors. However, the existence of healthy competition at the end of the telecom collapse is essential to the hypothesis that poor management decisions and not some other factor such as incumbent behavior or inadequate regulation were responsible for the demise of numerous individual firms.

Dr. Crandall believes that he has identified firms that will succeed and provide the necessary competition. The Sections below demonstrate that his analysis of the winners was premature. Moreover, the claim by the ILECs and Dr. Crandall that the Act is working under current regulatory policies, despite the collapse of many of the individual competitors, requires both successful survivors and competition across all or most local geographic and service markets. The evidence shows that, absent UNE competition, most consumers will be left behind even if many currently configured CLECs survive.

2. CLEC Survivors

As noted above, Dr. Crandall believes that mass scale mismanagement was the principal cause of the telecom collapse, while at least some of the competitors blame the incumbents, public policy, or both. Dr. Crandall attempts to make his case for the ILECs by identifying a set of firms that appear to have survived the collapse with solid future prospects. The three firms singled out by Dr. Crandall are Time Warner Telecom ("TWT"), McLeodUSA, and Allegiance.

A more detailed, and updated, look at Crandall's three poster children for competition demonstrates that there is something more fundamental about the telecom collapse than simply bad management or a normal shakeout. Each of

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After the Passage of the Telecommunications Act," June 2001 ("Crandall"), p. 4.

the three firms find themselves with dramatically reduced valuations since Dr. Crandall presented his analysis, both in absolute terms and relative to the overall stock market. In fact, McLeod has filed for bankruptcy and is selling assets.[84] Between June 1, 2001 and September 10, 2001 McLeod, TWT and Allegiance lost respectively 100 percent, 53 percent and 34 percent of their market value. The S&P 500 lost 13 percent of its value in this period. Since September 11 the major stock market indices have recovered the post-attack losses while the shares of these three companies show extended declines, with the shares of TWT and Allegiance down by 71 and 67 percent, respectively.

Table VII.1
Competition Poster Children

Loss in value	From 52-week high	From 6/1/ 01	Between 6/1/01 and 9/1/01	After 9/10/01
MCLD	100.0%	100.0%	94.7%	100.0%
TWTC	89.0%	84.4%	53.1%	66.8%
ALGX	69.4%	80.4%	33.6%	70.5%

These reduced valuations go hand in hand with the reduced business prospects the companies face. Since Crandall's June 2001 paper was written, TWT's fortunes appear to have taken a dramatic downward turn. On August 7, 2001, Reuters reported that "shares of Time Warner Telecom, Inc. fell almost 9 percent on Tuesday, a day after the telecommunications company posted a 55 percent decline in second-quarter earnings and cautioned that customer bankruptcies and economic weakness may dampen revenues through the end of

[84] "McLeodUSA Reaches Agreement with Bondholder Committee," McLeod press release, January 31, 2002, http://www.mcleodusa.com/html/ir, viewed March 13, 2002. ". . . [T]he company today has filed a pre-negotiated plan of reorganization through a Chapter 11 bankruptcy petition filed in the United States Bankruptcy Court for the District of Delaware."

the year."[85] The same article noted that one analyst reported "Time Warner Telecom's second-quarter additions of new customers and buildings connected to its network 'were below historical trends' . . ."[86] As a result, of these problems, the company cut its capital spending plans by almost 10 percent. Even before declaring bankruptcy, McLeod announced that it will " . . suspend network buildout outside the firm's 25-state service area . . ." and substantially reduce capital spending.[87]

Allegiance distinguishes itself from the other two carriers in that its stock is off by "only" 80 percent since Dr. Crandall studied it. In downgrading the stock based on management's reduced revenue estimates, Dain Rauscher Wessels noted that "the 2002 reduction is only partially explained by the events of September 11, and that weakening fundamentals in the form of lower sequential line growth and/or slower data-related growth may also be factored into management's cautious guidance."[88]

As this review shows, the firms Dr. Crandall has identified are suffering along with the rest of the CLEC community. This raises the following question: How have these and other survivor firms avoided or delayed collapse and why did they appear stronger than their peers did in June? One answer appears to be that in each case these firms benefited from the timing of their capital financing.

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[85] "Time Warner Telecom Shares Fall 9 Percent," Rueters, August 7, 2001.
[86] Ibid.
[87] "McLeodUSA Cuts Back Spending Plans, May Sell Assets To Stretch Funding" TR Daily, August 2, 2001.

Each of these firms was able to finance their operations at or near the peak of the NASDAQ bubble. For example, in February of 2000 Allegiance raised almost $750 million with a common stock offering at $70 per share (compared to a current price of $3).[89] Similarly, Time Warner Telecom completed a sale of $483.9 million in common stock at a share price of $74.44 in January of 2001. Finally, McLeod raised 750 million dollars on a January 2001 sale of notes.[90] This timing was either fortunate or prescient for the firms, but their good fortune is likely a one-time event.

Diversification provides another possible answer for the delay in the devaluation of these firms. Allegiance has a significant web hosting, Internet access and high-speed data business. According to McLeod's year 2000 Annual Report, the firm derived only six percent of its revenue from local exchange services, down from 11 percent in 1998.[91]

In addition to analyzing these individual case studies, Dr. Crandall performed regression analyses intended to identify the characteristics of successful firms. He concluded that there is ". . . very strong evidence that CLECs are best able to produce revenue growth by building their own networks

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[88] Dain Rauscher Wessels, "Reducing Revenue Estimates; Downgrading to Neutral," September 27, 2001.

[89] See. "Allegiance Telecom Underwriters Exercise Over-Allotment Option to Purchase 803,109 Shares of Common Stock" Allegiance Press Release, February 29, 2000, http://www.algx.com/about_allegiance/in_the_news/news_archive/2000/over_allotment.jsp. . Current stock price as of March 14, 2002, http://www.Reuters.com/quote.jhtml?ticker =ALGX.

[90] See, Securities Exchange Commission (SEC"), EDGAR Database, McLeod USA Inc., SEC Form 10-Q, August 14, 2001, p. 16, http://www.sec.gov/cgi-bin/srch-edgar.

[91] McLeodUSA, Inc., "Annual Report and Form 10k, Year 2000", p. 42, http://www.mcleodusa.com/media/ir/2000annualreport, viewed March 13, 2002.

or significant parts of their own networks."[92] However, many of the firms that are now in Chapter 11 proceedings also owned their own facilities. Winstar and Teligent were building fixed wireless networks using their own facilities. ICG, a fiber carrier just now emerging from Chapter 11, builds local fiber networks. Other carriers who build local fiber such as XO Communications are in severe financial distress.[93] Having facilities does not appear to be a sufficient condition for success.

In summary, even the well-managed CLECs identified by Dr. Crandall are in financial difficulty. As Dr. Crandall would surely agree, the financial health of individual competitors is only interesting to the extent it affects the state of competition. In this case, there is reason for alarm. Local telecommunications competition, particularly the facilities based competition that Dr. Crandall endorses, requires investment. Investment can only be made by firms that can attract capital. Many CLECs have run out of capital, and the remaining CLECs are cutting back their expansion plans.

The fact that even the CLECs that Dr. Crandall identified in June as being successful are cutting back their expansion plans and will have a difficult time raising new equity in the current environment suggests that, at a minimum, competition will develop more slowly than anticipated. It is possible that these competitors will cease to grow altogether. The service disruptions that have

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[92] Crandall, p. 4.

[93] See, SEC, EDGAR Database, XO Communications, SEC Form 8k, December 13, 2001, p. 5, "On December 13, 2001, XO Communications, Inc. ("XO") announced that it had requested to voluntary delist its stock from the NASDAQ National Market." http://www.sec.gov/cgi-bin/srch-edgar.

occurred as a result of the CLEC failures that have already occurred will make it more difficult for CLECs to expand in the future as customers will become more risk averse. Moreover, the current economic slowdown is affecting all telecommunications firms, but is likely to have the greatest impact on the newer entrants.

Dr. Crandall argues that the silver lining in CLEC bankruptcies is that other CLECs will be able to acquire assets at bargain basement prices. This is true to the extent the investment is not sunk. However, much of the investment may in fact be sunk and unrecoverable. One of the most important assets of these firms is human capital. To the extent their precarious financial condition or the need to reduce staff has caused employees to leave, their ability to compete is correspondingly reduced.

Nevertheless, Dr. Crandall is correct that switches may be re-deployed and fiber added to the networks of the survivors at low cost. Firms that are able to emerge from bankruptcy will be able to compete with reduced debt burdens. The problem, however, is there was already substantial <u>redundant</u> fiber and switching capacity. Most of the CLECs that have built actual transmission facilities have built them in core urban areas. Several carriers have installed fiber running down K Street in Washington DC. For one of the carriers to acquire the fiber of another at low cost does nothing to bring more competition to those portions of the Washington suburbs where competitive fiber has not yet been installed. One key to expanding local competition is, of course, to extend networks to customers that do not already have competitive alternatives.

E. Conclusion

It is becoming more and more apparent that local competition for the vast majority of customers must come from something other than the traditional CLEC model. The fiber rings that CLECs construct do not provide a cost-effective means for reaching customers in areas with lower line densities. The residential and business customers that populate these areas spend less on telecommunications. At the same time, it costs more to serve them because economies of scale in transmission are not available. This higher cost makes it very unlikely that competitors will build or extend fiber rings to serve customers outside of areas with large concentrations of business lines.[94]

VIII. Broadband Competition

Consumers are increasingly adopting broadband technology. This Section describes current competitive conditions in the broadband market. Although the cable industry has been successful in providing broadband services to its customers, broadband markets are far from being classified as competitive. Many customers depend on the ILEC broadband DSL services.

An important consideration is that CLECs may be able to use the ILEC DSL platform to offer a substitute for traditional narrowband voice service. ADSL and other forms of DSL (*e.g.*, g.shdsl) can support packetized voice (voice over Asynchronous Transfer Mode (“ATM”), typically). This means that with a local interconnection agreement, the ISP providing broadband service to consumers can engage in intramodal competition by providing its customers local service as well as the high profit vertical and ancillary services provided by the ILEC such as voice mail and custom calling features.

Appropriate UNEs at acceptable rates that allow CLECs to provide broadband DSL services must, of course, be available both to provide consumers with enhanced competitive broadband options and to perhaps allow intramodal voice competition in the future.

Section A discusses competition in the broadband market while Section B describes how DSL-based services that compete with the ILEC local services can be provisioned.

A. Broadband Competition[95]

There is very little broadband service competition today. DSL services provided over the ILEC network are often the only broadband alternative available to residential and small business consumers. In those areas where cable modem services are also available, the result is a duopoly. In those extremely limited cases where both fixed wireless Internet and cable modem service are available, consumers are limited to only three choices. As discussed below, satellite services are an inferior option for most consumers. The implication is that ILECs will not be forced by competition to open their broadband networks to CLECs for the purpose of providing a DSL substitute for the ILEC narrowband voice services.

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[94] See, ELB II.
[95] This Section draws on the Declaration of A. Daniel Kelley, filed with the FCC on behalf of WorldCom, *In the Matter of Review of Regulatory Requirements for Incumbent LEC Broadband*

The first step is to evaluate the various technologies used to provide broadband services. Several technology platforms are being used to provide broadband service. Broadband service facilities are currently supplied by ILECs using DSL, cable companies using cable modems on upgraded cable plant, fixed wireless companies using MMDS/ITFS and ISM spectrum, as well as satellite providers. Each of these platforms is arguably in the relevant broadband service market.

Other technology platforms should not be included in the market. Mobile wireless companies do not currently supply broadband access and will not do so in the next few years. Firms providing fiber to the home ("FTTH") service, which are essentially cable overbuilders, have an insignificant market presence today.[96] Gigabit wireless technology using 'pencil-beam' waves in the upper millimeter-wave bands (frequency spectrum above 70 GHz) shows promise,[97] but commercial deployment awaits Commission action on spectrum licensing.

Not all of the technology platforms included on the supply-side of the market are equal. Each technology has different quality and speed characteristics and each faces different economic challenges. Both satellite broadband and fixed wireless services face severe limitations.

Satellite service is available to consumers with generally southern exposure; i.e., no hills, trees, buildings, etc. in line of sight to the satellite. While

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Telecommunications Services, CC Docket No. 01-337, March 1, 2002. ("Kelley Broadband Declaration")

[96] These firms may also be having difficulty raising capital. See Steve Caulk, "Cable Firm Ceased Building," *Rocky Mountain News*, March 6, 2002.

there are currently two choices of satellite provider in many parts of the country, the service is significantly more expensive than either cable or DSL. Typical monthly rates are $75.00 for a service that provides downloads at 400-500kbps and upload at 128kbps. This service is thus priced higher and provides lower quality than the other broadband services. A $40.00 per month service is also available, but that requires upload through a separate dial-up telephone line at whatever modem speed is available over a switched telephone network connection.[98]

Costs of satellite installation are about $500-$525 for equipment and $200 for installation. The equipment, once purchased, belongs to the customer, but it can only be used for the satellite service for which it was purchased. In other words, the equipment is not interchangeable between satellite service providers. If the customer no longer wants the service, or wants to switch providers, he or she is stuck with the equipment. Professional installation is required, and a three-week wait for installation is typical. The high cost and delay associated with installation constitutes a significant barrier for most consumers.

These problems are reflected in the results of a recent survey conducted by PC World Magazine. PC World Reports that "the runt of the broadband litter has always been satellite. Characterized by difficult, expensive installations, notoriously poor service, and suspect performance, the service meant for anyone

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[97] See, *Request for Amendment of the Commission's Rules for the Point-to-Point Use of the 71.0-76.0 GHz and 81.0-86.0 GHz bands*, Petition of Loea Communications, RM-10288.
[98] See Brad Grimes, "Ditch Your Dial-Up," *PC World*, February 2002. http://www.pcworld.com/features/article/0,aid,73865,pg,3,00.asp, viewed February 27, 2002 for a discussion of broadband service features and prices.

who can't get cable or DSL has ceased to be a serious option."[99] In conclusion, it appears that satellite broadband is at best an alternative suited mainly for customers in rural areas or other areas where no other broadband alternative is available.[100]

While fixed wireless shows promise, it too faces significant limitations. Fixed broadband wireless systems, operating primarily in MMDS/ITFS and ISM spectrum, offer Internet access and other broadband data services to customers in selected markets. Such markets typically include businesses in large to medium cities and residential/business users in smaller markets. For reasons discussed earlier, these systems do not have the capacity to serve large fractions of the broadband demand in medium to large markets. Furthermore, current equipment used in these frequency bands requires line-of-sight paths between the system hub location and subscriber locations, thus further restricting the market they can serve. The implication is that the maximum penetration of fixed wireless services in larger markets will be limited to five to ten percent.

This upper bound on fixed wireless penetration obviously limits the competitive significance of the service. For these reasons operators of such systems, including WorldCom, view their service as being complementary to DSL service instead of being in direct competition. While WorldCom continues to market and operate its business-oriented MMDS/ITFS broadband service, Sprint

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[99] *Ibid*.
[100] Also see Jerry A. Hausman, J. Gregory Sidak, and Hal J. Singer, "Residential Demand for Broadband Telecommunications and Consumer Access to Unaffiliated Internet Content Providers," *Yale Journal on Regulation*, Winter 2001, pp. 129-173. ("Hausman, Sidak and Singer"), at p. 153.

has ceased marketing its service, which it originally marketed to residential as well as business users. Hybrid Networks, a prominent manufacturer of radio equipment designed to support broadband data transmission in these frequency bands, announced that it will cease operations at the end of April, 2002.[101]

So-called "Wi-fi" wireless local area networks ("LANs") have recently received publicity.[102] These networks are based on the Institute of Electrical and Electronics Engineers ("IEEE") 802.11b standard and operate in the 2.45 GHz ISM band. Wi-fi systems, sometimes referred to as "wireless Ethernet" (because part of the standard has its roots in the Ethernet standard IEEE 802.3), usually are intrapremises systems. Such systems may be intended for public or private use. A private corporation, for example, may use an 802.11b network within a building as a wired LAN replacement.

Public wireless LANs are becoming more common, with Starbucks coffee shops being possibly the most visible of companies using 802.11b to provide customers access to the Internet while they patronize Starbucks shops. In the Starbucks example, the wireless LAN exists to support wireless connections to an "access point" that connects to a wireline broadband facility such as an ADSL connection. The private network case also requires similar access points to allow LAN users access to other networks. In either case, the wireless LAN just replaces premises wiring and does not represent a fixed wireless bypass of an ILEC's network. Their attractiveness is in their relative ease of installation, which

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[101] "Hybrid Networks to close doors in April,"www.rcrnews.com, March 29, 2002.

requires minimal cabling, as well as the fact that they are unlicensed systems operating under Part 15 of the FCC's rules.[103]

There are also a few examples of 802.11b systems used for metropolitan area networks. These systems have limited capacity per hub location, typically around 1600 subscribers assuming an eight-sector hub and 256 kbps service used for Internet access with no quality of service guarantees. Even with a coverage radius of one or two miles,[104] this limited capacity cannot begin to support significant penetration of the fixed broadband market. Furthermore, these systems (along with those used as indoor LANs) have the fundamental drawback that subscribers have no recourse under the Commission's rules when they suffer interference. This fact, in conjunction with the increasing volume of unlicensed communications equipment, including cordless telephones and wireless LANs, generally makes these bands unsuitable for "carrier-grade" communications services, including voice and data, for significant numbers of subscribers.

B. Voice Over DSL Technology

Broadband competition is important in its own right and public policy should be designed to encourage it, at both the wholesale and the retail level. Another possible consumer benefit is the potential for CLECs to use the ILEC

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[102] See, *e.g.*, Amy Harmon, "Good (or Unwitting) Neighbors Make for Good Internet Access," and John Markoff, "The Corner Internet Network vs. the Cellular Giants," both in the *New York Times*, March 4, 2002, p C1.

[103] 47 C.F.R. §15 (2001).

[104] The area covered by a Part 15 system is necessarily small because of the low-power transmitter required by the rules. In contrast, an MMDS-based system can support a much larger

broadband DSL platform to compete with in traditional local service markets. This potential form of intramodal competition may provide an additional incentive for ILECs to frustrate the unbundling of their broadband facilities.

Most ADSL service implementations are ATM-based. The subscriber modem is connected to a digital subscriber line access multiplexer ("DSLAM") located in the wire center, in the case of an all-copper loop, or in an ADSL-compatible digital loop carrier ("DLC") remote terminal ("RT"). The DSLAM in turn is located at the edge of an ATM network.

Appendix C contains a discussion of the various service classes that ATM supports and gives examples of the kinds of applications that the service classes can support. The Appendix also shows that ILECs, in their DLC-based DSL wholesale offerings, typically allow CLECs access to only the most basic ATM service class, which is suitable only for casual Web browsing and email access.

The ILECs are, obviously enough, free to offer whatever class of service they choose for their own services, while withholding these from potential competitors. While CLECs are restricted from offering anything but the most basic ATM-based data transmission services, the ILECs can support packetized voice and video, streaming video, and other advanced services with associated quality of service guarantees.

coverage area, with a nominal radius of thirty miles or more, given suitable local terrain and antenna siting.

IX. Oligopoly in Local Markets[105]

Even in those cases where the consumer has a competitive alternative, in the form of cable, for example, the underlying competition is not likely to be robust. That is, the carriers are likely to have significant market power. The inadequacy of a facilities duopoly for ensuring consumer choice can be demonstrated in several ways. As a theoretical matter, duopoly is much more likely to lead to monopoly behavior. Game theory models show that when markets are occupied by a relatively small number of competitors, performance can suffer. In many models a competitive result requires several carriers to be in the market. The price-cost margin in the standard Cournot model of oligopoly interaction is inversely related to the number of competitors.[106] In other words, a duopoly in the broadband service market is not likely to perform competitively.

Game theory models typically assume that the competitors recognize their interdependence, but do not explicitly coordinate their behavior. This means that the resulting prices, while higher than the competitive level, may fall short of the monopoly profit maximizing level. By learning how to coordinate their actions, oligopoly firms may be able to raise prices above the Cournot level.

A number of factors facilitate the necessary coordination. The basic requirement, of course, is small numbers. In addition, if prices are visible to all the competitors, then cheating on any tacit agreement will be detected and therefore less likely to occur. Similarly, if the firms compete with one another in

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[105] See Kelley Broadband Declaration.
[106] See, e.g., W. Kip Viscusi, John M. Vernon and Joseph E. Harrington , Jr., *Economics of Regulation and Antitrust*, Third ed., MIT Press, Cambridge, MA 2000, p. 108.

multiple markets, then they will be less likely to compete aggressively in any one of them due to the risk of retaliation.[107] Each of these facilitating factors is present in the local exchange business. Prices are well known to all competitors. Even without tariffs, the mass-market nature of the services generally requires standardized offerings. ILECs, cable companies and wireless providers are interconnected through multiple market contacts.

Among the harshest critics of oligopoly performance are the ILECs. They have been complaining about performance in the long distance market for years, sponsoring studies allegedly showing that this market performs poorly because it is concentrated.[108] Many disagree with their empirical assessment. The long distance market has dozens of competitors in a nation-wide market. Entry barriers are relatively low and prices have fallen substantially. However, the economic theory underlying these ILEC claims is correct. As Professor Hausman concludes, oligopoly facilitates coordinated interaction among competitors.[109] Given the high barriers to entry and the small number of competitors in local service markets, unregulated oligopoly, and particularly

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[107] See, e.g., F. M. Scherer and David Ross, *Industrial Market Structure and Economic Performance,* 3rd ed., Houghton Mifflin, Boston 1990, p. 315.

[108] See Testimony of Jerry A. Hausman, on behalf of Pacific Bell (u 1001) May 19, 2000, Before the Public Utilities Commission of the State of California, *in re request of MCI Worldcom, Inc. and Sprint Corporation for Approval to Transfer Control of Sprint Corporation's California Operating Subsidiaries to MCI WorldCom, Inc*. Application No. 99-12-012, p. 12. ("Hausman California Testimony"). See also, *Application by New York Telephone Company (d/b/a Bell Atlantic – New York), Bell Atlantic Communications, Inc., NYNEX Long Distance Company, and Bell Atlantic Global Networks, Inc., for Authorization to Provide In-Region, InterLATA Services in New York,* Declaration of Paul W. MacAvoy in Support of Bell Atlantic's Petition to Provide In-Region, InterLATA Telecommunications Services, CC Docket 99-295, September 1999.

[109] See Hausman California Testimony, p. 12. Hausman points out that "the industrial organization literature has explored how, with only two firms, detection of cheating from an agreement is simplified." Citing, A. Jacquemin and M.E. Slade, "Cartels, Collusion, and

duopoly performance by the ILECs and cable companies, can be expected to be poor.

There is empirical evidence from another telecommunications market that a duopoly does not provide competitive performance. Incumbent cellular providers, of which there were originally a maximum of two in each service market, argued that prices were competitive prior to entry by PCS carriers. However, pricing information collected by the FCC shows that prices declined over 50 percent in the five years since PCS entry began in 1995.[110] As the Yankee Group reported, "the rollout of PCS service encouraged the cellular carriers to speed conversion to digital, reduce prices, and offer more services."[111] It is reasonable to infer that the increase in competition when the market increased from two to as many as six or seven carriers was dramatic. There would be less concern about a duopoly of facilities-based providers of local services if competitors could rely on nondiscriminatory access to unbundled network elements to provide service to their customers.

X. UNEs Are Necessary

From an economic perspective, the ILEC network should be unbundled when doing so provides an opportunity to materially improve consumer welfare. Unbundling can improve consumer welfare by allowing competition for features

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Horizontal Merger," in R. Schmalensee & R. Willig, *Handbook of Industrial Organization,* Elsevier Science Pub. Co., New York 1989, Chapter 7.

[110] *Before the FCC, In the Matter of Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Service*, FCC Document 00-289, Fifth Report, 15 FCC Rcd. 17660 (2000).

[111] See Mark Lowenstein and Adam Zawel, "The Impact of PCS Service on U.S. Wireless Pricing," Yankee Group, September 2, 1999, p. 66.

and functions as well as by allowing cost competition for those elements of the service that the CLEC provides itself (e.g., customer service and billing). Moreover, unbundling will allow the CLECs to put together packages of local, long distance and broadband services that differ in materially ways from those that an integrated ILEC would offer. Of course, if only the ILEC can offer such packages, the ability of CLECs and IXCs to compete for significant classes of customer business would be reduced, with likely consequent reductions in consumer welfare. Finally, as discussed elsewhere, since unbundled elements are a complement to CLEC facilities-based services, offering unbundled elements can reduce barriers to entry and stimulate competition.

Refusal by the ILECs to unbundle would be consistent with improving consumer welfare only in two cases. First, if there are sufficient alternative competitive local service platforms to provide consumers with an array of choices, then unbundling would be unnecessary.[112] Second, if the ILEC could demonstrate that unbundling entails costs that exceed the benefits of added choice, then unbundling would not be required under a consumer welfare test. Sections V-VIII above demonstrate that competitive options are not sufficiently robust to make unbundling unnecessary. ILEC efforts to document costs that exceed the benefits of unbundling have been unpersuasive to regulators. The argument that unbundling deters efficient investment, and thus would harm consumer welfare is discussed below in Section XI.

[112] As discussed elsewhere, if there were sufficient alternative local platforms it would be likely that ILECs would voluntarily unbundle in order to compete more effectively with the competitors who owned their own loop facilities.

The legal standard for unbundling under the 1996 Act and court rulings may differ from the economic standard just discussed. Under the Act an element should be unbundled if CLEC ability to offer a service would be materially impaired.[113] Without delving into the legal details, it appears that the legal and the economic standards discussed above are consistent.

CLECs desiring to provide competitive services would be much less effective in doing so without access to UNEs. Consider a new firm formed for the purpose of offering local services that is not affiliated with any incumbent. Cable and wireless links to the consumer are generally not available or do not provide the capacity or the quality necessary to provide consumers with adequate alternatives to the incumbent's services. Therefore, the ability of the CLEC to compete would be impaired if it did not have access to UNEs. With such access, the new entrant CLEC could offer bundled or unbundled service packages to consumers, perhaps with the intention of building its own facilities where economic.

Defining the particular elements that must be unbundled is beyond the scope of this Report. In general, UNEs that a CLEC needs to provide traditional narrowband services, broadband service for Internet access, and high-capacity services for large business customers are required. The case for unbundled loops is obvious given the major barriers to CLEC entry in all but the densest zones, and the difficulty of expanding even within these zones. The discussion in

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[113] 47 U.S.C. §§ 251(d)(2)(A) and (d)(2)(B). See also, *In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98,

Section VII shows that even the transport function exhibits substantial economies of scale. A recent Z-Tel analysis shows that the Commission's existing restriction on unbundled switching has reduced competition.[114] None of the markets in which these elements are offered is sufficiently competitive to allow an efficient wholesale market to operate. The brief history of the post-1996 Act period conclusively demonstrates that the ILECs will not provide the necessary UNEs to CLECs without intervention by regulators.

This fact alone demonstrates that claims that these facilities are abundant and virtually ubiquitously available are false. If the facilities competition and low barriers to entry and expansion that the Petitioners allege were real, then the ILECs would be anxious to make unbundled network elements available at economic cost to CLECs in order to generate demand on their own networks. Since they do not, and there are not sufficient viable alternatives to guarantee consumers a competitive result, unbundling is required.

The need to unbundle high capacity lines for use by CLECs is the only area where there might be any controversy. But even in this case, using the example of serving a large bank with branch offices throughout the city it was demonstrated in Section VII that unbundling is required.

As the demand for high-speed data services grows, and high-capacity demand is growing across the board, including in areas that the CLEC networks currently do not serve, the availability of high-capacity UNEs can help overcome

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Third Report and Order and Fourth Further Notice of Proposed Rulemaking, 15 FCC Rcd. 3696 (1999) ("*UNE Remand Order*"), para. 15.

the substantial barriers to expansion. If traffic can be added to network at an efficient cost through UNEs, it is more likely that the network will be built in the first place.

XI. Unbundling At Economic Cost Will Not Deter Efficient Facilities Construction by Either ILECs or CLECs

ILECs and others have argued that unbundling and TELRIC pricing will deter investment by both ILECs and CLECs. Section A addresses the incentives that CLECs have to build facilities when UNEs are available. Section B deals with ILEC incentives to build new facilities when they are subject to the UNE provisioning and pricing rules. The fact that ILECs do not want to provide facilities even though they would receive an economic return is explained in Section C.

A. UNEs Do Not Reduce CLEC Incentives to Construct Facilities

ILECs have suggested that making UNEs available reduces CLEC incentives to construct their own facilities. If true, this could delay the onset of full facilities-based competition. The ILEC argument is incorrect. Withdrawal or overpricing of UNEs will not encourage the CLECs to build facilities that they would otherwise not build. Simply put, if it is not economic to enter by constructing facilities, then the CLECs will not enter. Only if UNE prices are set below economic cost would CLECs have an incentive to postpone otherwise efficient construction of new facilities.

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[114] See “An Empirical Exploration of the Unbundled Local Switching Restriction,” Z-Tel Public

It should also be noted that artificially high UNE prices would not induce entry, even if the CLECs can produce services at a cost in between the ILECs' TELRIC costs and the artificially high UNE prices. It would be foolhardy for the CLECs to do so because they would anticipate that the ILECs would lower prices in response to entry, and cause them to lose money.

Withdrawing UNEs would actually have the effect of reducing CLEC investment. ILEC UNEs are in some cases a complement to CLEC facilities, in effect allowing CLECs to obtain the benefits of ILEC economies where the CLECs cannot efficiently construct their own facilities. In some cases, only by combining unbundled ILEC facilities with their own, can the CLEC achieve the economies needed for successful entry. Denying CLECs the opportunity to use this complementary input only reduces the incentive and ability of CLECs to invest in their own facilities.

It must be remembered that facilities construction by competitors is not desired for its own sake. The investment enhances consumer welfare only if the competitor is ultimately as or more efficient than the incumbent. If the presence of substantial economies of scale dictate that there be only one supplier, then entry by a second facilities-based firm will generally not add to consumer welfare.[115]

Firms might enter in the face of substantial incumbent economies of scale in some circumstances. For example, if the firm believes that it has other

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Policy paper No. 3, November 2001.

advantages that can compensate for its higher costs, or if it expects to achieve its own economies over time, it will enter anyway. But pricing UNEs above costs or withdrawing them from the market (the equivalent of an infinite price) will not change this calculation.

B. UNEs Do Not Reduce ILEC Incentives to Construct Facilities[116]

The ILECs argue that being forced to make UNEs available at economic cost reduces their incentives to invest in new facilities. Three related arguments are advanced. First, the ILECs argue that TELRIC prices are inherently inappropriate. That is, they are incapable of sending the right signals to the market, either because it is too difficult to estimate them properly or because the concept itself is flawed. Second, they argue that investment in facilities will be stranded once CLECs build their own facilities, leaving ILECs with unrecovered investments. Third, they argue that forcing the ILEC to sell the facilities incorporating new technology at TELRIC prices denies them the opportunity to be compensated for the risk they have taken. Each of these arguments are discussed below, beginning with the allegation that TELRIC is inherently flawed.

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[115] Entry by firms reselling the monopolist's services or using its network elements facilities could provide consumer welfare benefits by giving consumers additional choices and the benefit of retail competition.

[116] These issues are discussed by William J. Baumol, "Response to the NTIA Request for Information on Broadband." (Baumol Paper") See, U.S. Department of Commerce, National Telecommunications and Information Administration ("NTIA"), *Notice, Request for Comments on Deployment of Broadband Networks and Advanced Telecommunications*, Docket No. 011109273-1273-01, November 14, 2001 ("*NTIA Broadband Deployment Request*").

1. TELRIC Is an Appropriate Costing Concept

TELRIC is designed to compensate the ILEC for the economic cost of building and operating new facilities– as the Commission found in the *Local Competition Order*.[117]

The pricing principles underlying TELRIC are unassailable. In competitive markets, prices are based on economic cost, and implicitly on the investment and expenses that an efficient new entrant using modern technology would incur.[118] Higher prices would induce entry and lower prices would induce exit. Some telephone companies in the U.S. have criticized TELRIC because it does not rely on the existing telephone company infrastructure to compute costs. However, in a competitive market the existing infrastructure of any particular competitor is irrelevant to the pricing calculus. As discussed above, prices in a competitive market are based on the most efficient technology and practices. In other words, whatever technology was deployed or when or at what cost it was deployed do not affect prices in competitive markets. By advocating the measurement of costs using their existing network configurations, the ILECs are attempting to find ways to recover their embedded costs. If the FCC were to accept this, it would be putting the interest of a particular competitor ahead of the interests of competition.[119]

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[117] *Local Competition Order*, para. 685.

[118] Companies in the competitive U.S. long distance market have written off billions of dollars in investments as technology has progressed from analog microwave to digital microwave to and through several generations of fiber optic transmission technology.

[119] If the ILECs insist on setting prices based on their actual network, then they should compute a Long Run Incremental Cost ("LRIC"). This LRIC cost must be lower than TELRIC or else the ILECs would have already scrapped their entire network.

The ILECs can hardly oppose the application of economic pricing principles to regulatory pricing decisions. ILECs have historically advocated incremental cost pricing for services subject to competition and specifically rejected pricing based on embedded costs.[120]

Finally, if anything, as actually implemented, the TELRIC prices are conservatively high. TELRIC, as implemented by the FCC takes existing telephone company wire center locations as given. Thus, the modeled network is not as efficient as it could be. The TELRIC Models used by the states to estimate UNE prices are conservative in other ways as well. The states have generally, and in many cases inappropriately, adopted input cost assumptions that are too high or have otherwise approved UNE rates well above true TELRIC levels.

2. Stranded Plant Is Not A Real World Problem for the ILECs

Network unbundling is unlikely to produce stranded plant. To be stranded, an investment in an asset must be sunk. Switching capacity and electronics obviously can be reused or resold even if demand for other elements of the network declines. As a matter of first impression, loops appear to fit into the category of sunk costs. However, in reality, most loop plant is shared by numerous customers. Most feeder and distribution investment is common to all the loops provided. The wire pair serving a particular customer can be reallocated to another customer if the first customer's business is lost to a competitor. Only the drop and NID are unique to a particular customer.

[120] See Baumol Paper, p. 10. (Citing Federal and State decisions discussing BOC positions.)

However, even if that particular customer is lost to a competitor, the investment does not become worthless. It is an asset that can later be used to compete for the business of that customer or a new customer at that location at a later time.

It is also important to note that overall ILEC local network demand is unlikely to decline. The market is growing and experience with competition around the world demonstrates that incumbents typically do not lose actual business. Competitors generally take a larger share of incremental business. This is similar to experience in the long distance business. From the introduction of switched competition in 1978 to 1999, AT&T lost market share but continued to grow in absolute size.[121] With growing demand, switching, transport and most loop plant will not be stranded by losses of incremental business to competitors.

If ILECs are concerned about stranded plant, they should encourage entrants to use UNEs. If cross-platform competition is the threat they allege, then one way to compete is to unbundle and allow CLEC competitors to market network elements for them. A related point is that increasing prices to reflect an alleged options risk may be counter-productive for an incumbent because the resulting higher interconnection charges may simply accelerate the investment by competitors in networks of their own.

The ILECs also forget the fact that technological change can increase the value of existing assets. Digital switching made ILEC investments more valuable because it enabled the offering of high margin vertical and ancillary services such

[121] See Trends in Telephone Service, Table 10.7, p. 10-13.

as voice mail and custom calling features. Similarly, the demand for broadband connections has increased the value of embedded networks in recent years.

Finally, TELRIC rates include a return to capital that includes a risk factor and allow for the depreciation of investments. Thus the TELRIC tool is sufficiently flexible to account for the risks that the ILECs say they have. The weighted average cost of capital estimated by traditional means already reflects the introduction of competition and the advance of technology. These factors have been in the market for many years.[122] The ILECs have simply failed to marshal the evidence to convince regulators that rate should be higher. Instead, they have chosen to fight the concept.

3. Unbundling Is Consistent With Innovation Incentives

The argument that unbundling at TELRIC prices will deter ILEC innovation was made most recently by Alfred Kahn and Timothy Tardiff, in the context of broadband services. They maintain that "the more innovative the investments contemplated, the greater the uncertainties, both technological and commercial, the greater the risks, the more important is the prospect of the investor's exclusive enjoyment of the fruits of the ventures that turn out successfully."[123] As a matter of pure economic theory they are, of course, correct. Where the argument breaks down is in the application of the theory to the facts.

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[122] It should also be noted that the cost of capital in the models being used to produce TELRIC rates for UNEs has typically remained in the 10 to 12 percent range even though interest rates, which are a significant component of the cost of capital have fallen substantially in recent years.
[123] Declaration of Alfred E. Kahn and Timothy J. Tardiff, December 18, 2001, submitted to NTIA, para. 14.

The ILECs did not pioneer the type of broadband service that Dr. Kahn and Mr. Tardiff are discussing. The Internet, the development of which is driving the demand for broadband services, has evolved independently of the ILECs. The market position enjoyed by the cable companies demonstrates that they were in fact the leaders in taking the risks in deploying broadband services. Moreover, in terms of DSL, it was the CLECs who made the initial investments and took large investment risks in doing so. The ILECs have been followers. Now that the demand has been proven, largely due to the investments of others, they wish to prevent the original risk takers from using their networks.

It is also important to note that much of the technology risk inherent in deploying new ILEC telecommunications services has already been borne by the equipment manufacturers. ILECs are responsible for few innovations. They have depended on a competitive equipment market to come up with new process or service innovations.

The amount of the risk that ILECs must take in incurring capital expenditures to implement DSL is also questionable. On ordinary copper loops, the additional investment is both moderate and scalable. Where DLC systems are being used by the ILEC, operational cost savings can justify much of the cost of necessary network upgrades. In other words, ILECs have the incentives to make much of the investment whether or not they provide broadband services. The investments that are specific to broadband are again modest and scalable.

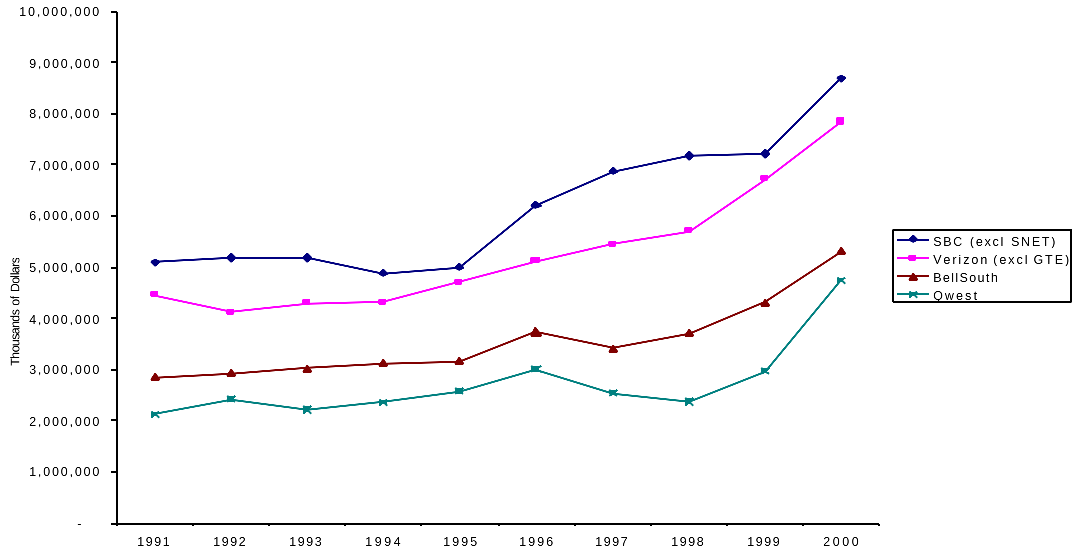
It should also be noted that many of the revenues from new services are from services that are not regulated. Rapid deployment of broadband will allow

ILECs to compete for the substantial unregulated revenue streams generated by ISPs and other firms serving broadband users. The ISP function includes arranging for consumer access to the Internet through local links. The ISP bills consumers for the connection and provides customer support functions. The ISP may also provide content and services such as customized web pages, web hosting, e-mail server provision, e-mail roaming, IP addresses (static or dynamic), access to domain name search and registration, browser and search engines, antispam software tools, Instant Messaging, streaming audio and video feeds, public radio station broadcasts, community bulletin boards and other local content, and technical seminars and workshops. The ILECs are free to make market returns on these services, but only if they make the investments necessary to allow consumers to have reasonably priced broadband service.

Finally, the ILECs' stated reluctance to roll out DSL services more rapidly, including DLC rollout, is hard to reconcile with their claims that the broadband market is competitive. By slowing the rollout of DSL plant, the ILECs are leaving the market open for cable.

In general, the unbundling requirements in the 1996 Act did not deter ILEC investment. Indeed, as the chart below shows, ILECs actually increased their investment activity after the Act passed. It is possible that much of this investment was due to the desire to provide broadband services in competition with cable companies and the data local exchange carriers ("DLECs").

Figure XI.1
Total BOC Plant Additions



C. Why Are ILECs Withholding UNEs from the Market?

If UNE rates provide the ILECs with a compensatory return, then why do the ILECs resist providing the services? The answer appears to be that the ILECs are withholding facilities not because UNEs are below the ILECs economic cost. They are withholding facilities because the UNE price is below the ILEC opportunity cost.

ILECs continue to earn substantial profits on their legacy lines of business. New technology, including DSL provided over their facilities by CLECs may be perceived as a threat to existing revenue streams. One example is T1 rates. T1s are provided over ordinary copper loops (and DLC) using DSL technology. The ILECs charge high rates for these services. For example, in Illinois, a five mile DS-1 circuit will cost $316 per month.[124] Making the constituent parts

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[124] Based on Zone 2 and a five year term commitment.

available for resale through unbundling will put these high returns at risk. The ability of ISPs or CLECs to use unbundled broadband elements and resold DSL services to compete for high margin local service customers using voice over DSL, as discussed in Section VIII, will also result in arbitrage.

This is, of course, exactly what unbundling and resale policies are supposed to do. Unbundling and resale applied to AT&T's long distance service in the early days of long distance competition led to significant changes in AT&T's rate structure, and significant benefits to consumers.

So the answer is that ILECs resist UNEs not because they cannot earn a competitive return on them, but because they risk losing a monopoly return on their existing services.

Appendix A – Traffic Demand Estimates

According to the Cellular Telecommunications and Internet Association ("CTIA"), the average duration of a completed wireless call as of June, 2001, is 2.62 minutes[1] and average monthly usage is about 422 minutes/month.[2] Using a conservative assumption of twenty-two days per month and a 70% call completion fraction (*i.e.*, 70% of all call attempts result in a completed call) and a further assumption that 10% of daily traffic falls in the busy hour, an average wireless offered traffic load per subscriber is computed as SHOWN IN Table A.1:[3]

Table A.1
Wireless Offered Load per Subscriber

Average completed calls/month	= 422 minutes/month ÷ 2.62 minutes/completed call = 161 completed calls/month
Average completed calls/day	= 161 completed calls/month ÷ 30.4 days/month = 5.3 completed calls/day
Average completed calls/busy hour	= 5.3 completed calls/day × 0.1 = 0.53 completed calls/busy hour
Average call attempts/busy hour	= 0.732 completed calls/busy hour ÷ 0.7 completed calls/call attempt = 0.76 call attempts/busy hour
Average offered traffic/sub	= 0.76 call attempts/BH × 2.62 min/call × 60 s/min ÷ 100 s/CCS = 1.19 CCS, or about 1.2 CCS.

[1] Cellular Telecommunications and Internet Association (CTIA), "CTIA's Semi-Annual Wireless Industry Survey Results – June 1985 to June 2001," ("CTIA Survey"), available at http://www.wow-com.com/industry/stats/surveys/. Although more recent estimates of penetration are available, CTIA's June, 2001, numbers are used for consistency.

[2] See, *e.g.*, Jeffrey Selingo, "Complaints skyrocket along with cellphone use," *The New York Times,* reprinted in *The Denver Post,* February 18, 2002.

In comparison, typical wireline telephone per-subscriber offered loads range from around 3 CCS to 10 CCS or more, depending on whether the service is business or residential, and what features the subscriber has selected. For example, the Call Waiting feature (which inserts a tone into the called party's end of an active telephone call to let the subscriber know another call is waiting) can increase the per-subscriber traffic by a factor of two to four or so. Business lines typically exhibit higher offered loads than do residential lines.[4] This is assuming an average (business and residential) offered load per wireline subscriber of about 3.6 CCS, which is three times the conservatively-estimated 1.2 CCS per wireless user.

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[3] See, *e.g.*, Telcordia Technologies, *LSSGR: Traffic Capacity and Environment*, GR-517-CORE, Issue 1, December, 1998, for discussions of telephone subscriber traffic characteristics.
[4] *Ibid.,* p 6-8.

Appendix B – Wireless Network Capacity

As of June, 2001, there were about 118 million cellular and personal communications service ("PCS")[1] subscribers in the U.S. served by about 114,000 cell sites.[2] The average number of subscribers per cell is thus just over 1,000. Obviously, there is a wide variance in the actual number of subscribers per cell. Many rural cells will serve very few subscribers, and urban cells will serve considerably more than the nationwide average. In rural Western areas, for example, there are cells that only cover major highways to serve roamers, and there may be no, or very few, "permanent" subscribers residing in the cell coverage area. For the purposes of this capacity analysis, however, 1,000 subscribers per cell is assumed. This is a very optimistic approach, as it leads to significant underestimates of the cell capacity required in urban areas just to serve existing wireless subscribers. The analysis will show that, even in this optimistic case, wireless systems cannot come close to serving both wireless and wireline demand in areas with urban and even suburban subscriber densities.

The following discussion of wireless network capacity is based on code division multiple access ("CDMA") radio technology as it is used in existing U.S. cellular and PCS systems. CDMA is used in our examples as it generally has somewhat greater capacity for a given amount of spectrum than competing

[1] In this section, the term "wireless" is used to refer to both cellular and personal communications mobile and portable service offered by service providers classified as Commercial Mobile Radio Service ("CMRS") system operators.
[2] CTIA survey.

technologies. It is, however, considerably more complex to analyze than are more conventional technologies.

All cellular and PCS technologies are designed to reuse frequencies in a serving area to attempt to maximize the use of the available spectrum. “Conventional” (time division multiple access (“TDMA”) and analog cellular) systems require significant physical separation between cochannel cells (cells using the same radio channels). CDMA systems can reuse frequencies in adjacent cells and even within a cell when cells are divided into angular sectors (see Figure B-1). This ability to reuse frequencies in adjacent cell coverage areas is the principal reason for CDMA’s capacity advantage over other technologies.

The capacity of a CDMA system, considered at the cell level, is difficult to estimate and depends on many parameters, including the amount of spectrum (number of radios) employed, the coding rate used for the digital voice coder, the number of sectors into which the cell is divided, cell transmitter power, and a number of others. In CDMA, subscribers occupy the same spectrum simultaneously, as opposed to, say, TDMA, in which each subscriber is assigned a time slot on a specified frequency channel for the duration of the call. Active CDMA subscribers thus generate mutual interference, and it is this interference which ultimately limits the performance and capacity of the system.[3] As shown in

[3] Note that there is generally no precise limit to the capacity of a CDMA system. Each active user generates interference for all other active users. As usage increases in a cell (and in surrounding cells), the interference level increases for all users, and signal quality can deteriorate to unacceptable levels, causing users to terminate their calls. This is analogous to a number of people trying to converse in a crowded room, in which all talkers share common (acoustic)

Figure B.2, interference is generated by users within a cell as well as by users in other cells. As user activity varies among cells, the effective capacity of a given cell will change. The capacity of a given cell will increase as activity in adjacent cells decreases and produces less interference; conversely, increased activity in adjacent cells will lower the useful capacity of the given cell. Also, the effective coverage area of the cell increases as average interference from adjacent cell decreases, leading to a well-known characteristic of CDMA systems often referred to as cell "breathing."

Using typical assumptions for the various system parameters as outlined in the previous paragraph, we estimate that a CDMA system will support about seventeen active users per radio. Under standard Erlang B assumptions, this corresponds to a per-radio traffic capacity of 384 CCS,[4] which can support about 320 users under our assumption of 1.2 CCS per mobile/portable subscriber. For our average cell demand of 1,000 users, four radios are required in an omnidirectional cell, leaving an excess capacity of 336 CCS for fixed users, or about 93 fixed users at 3.6 CCS/user.

If more than about four radios are required in a cell, carriers subdivide the cell into sectors, each of which is equipped with radios and antennas separate from those in other sectors. The most common approach is to equip three

spectrum simultaneously, and the interference from other conversations causes people to leave the room to carry on their conversations elsewhere.

[4] This assumes two percent blocking at the radio channel level, a typical design value for wireless systems. This is, of course, twice the overall blocking level one normally associates with wireline telephone service.

sectors. [5] In estimating the capacity of a CDMA sectored cell in which radio channels are reused in each sector, one generally applies a sectorization efficiency factor of 0.85, so that the capacity of the entire three-sector cell is 3 x 0.85) or 2.55 times the capacity of a single sector.

Technical and economic considerations limit the number of radios in a sector to about four. For a three-sector cell, the maximum capacity is thus 384 CCS/radio x 4 radios/sector x 2.55, or 3916 CCS. This capacity can serve 1,000 mobile/portable users and about 750 fixed subscribers.[6] If the cell has a nominal coverage radius of 1 km (0.62 miles), the wireline subscriber density capacity is only 620 subscribers/square mile, which is far below even what could normally be considered a suburban subscriber density. It is important to keep in mind that these values are based on severely optimistic assumptions regarding wireline subscriber traffic, existing wireless subscribers per cell in urban and suburban areas, and other factors.

Even with these optimistic assumptions, existing wireless systems cannot even approach the levels of capacity required to serve significant fractions of wireline users. If it is supposed that each of six wireless service providers in a

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[5] Although equipment vendors normally offer six-sector cell designs, they are rarely used as they are expensive and quite difficult to install and support.

[6] As noted elsewhere, the capacity estimates used in this report are based on a 9600 bps voice coding rate (known as Rate Set I), which provides voice quality that is apparently acceptable for mobile and portable use but is substandard in comparison with the overall voice quality of wireline voice service which uses a different class of voice coding techniques which usually operate at 64 kbps. The U.S. CDMA standards allow for a 14.4 kbps voice coder (Rate Set II) which offers voice quality that is somewhat better than that provided by the Rate Set I coder but which is still inferior to current wireline quality. If the radios added to each cell site to serve fixed users used the 14.4 kbps voice coders to attempt to meet subscriber expectations of voice quality, the number of active users per sector per radio becomes eleven instead of the seventeen used in the initial analysis. Note that this analysis is particularly conservative because, to the best of our knowledge, Rate Set I is not generally used in commercial service.

market assign as much capacity as possible in each cell to serve mobile/portable users and fixed users for only switched voice service, and that each uses cells with a nominal coverage radius of one kilometer (which assumes an absurdly dense arrangement of cell sites, given that six service providers are involved), the total supported fixed subscriber density is 6 x 620, or 3720 per square mile. This is a typical suburban subdivision density and does not come close to urban densities. It is especially important to note that this density could be served only if all carriers were to equip the practical maximum number of radios in a cell to serve relatively high-usage and equally relatively low-revenue fixed subscribers.

The preceding analysis assumed a nominal cell coverage radius of 1 km. The served subscriber density will obviously increase if the cell radius is smaller, and, in the absurd limit, one could claim (and some have)[7] that arbitrarily large subscriber densities could be served by continuing to reduce the average cell coverage radius. This ignores a number of economic and technical realities, including the difficulties in obtaining suitable real estate for cells in densely-populated areas, obtaining zoning and environmental approval for antenna masts, leasing or constructing backhaul facilities to connect cell sites with the wireless switching center controlling the wireless network, as well as solving the myriad technical problems arising from the need to pack a large number of radio carriers in a single cell, many of which become intractable at short cell spacings.

[7] *The Enduring Myth of the Local Bottleneck,* 1994, p 34 (unattributed). The author of this document states that ". . . cellular architecture is inherently expandable, like an accordion. The capacity of all cellular systems, including PCS, can be increased almost indefinitely by deploying additional cells and thereby reusing already-allocated spectrum." This statement reflects an acute lack of understanding of cellular radio technology and its practical limitations.

Initial forms of third generation ("3G") radio technology now being introduced by some carriers will not likely improve capacity to allow significant degrees of wireline service replacement. These new technologies are in fact not intended to do any such thing. The 1xRTT CDMA technology that is now in early phases of commercial deployment includes improved voice processing techniques that can increase voice capacity in a single 1.25 MHz carrier by up to a factor of two. 1xRTT also provides high-speed (144 kbps) packet data in the same carrier space. It is easy to misinterpret the advertised benefits of this technology: It does not simultaneously double voice capacity and add high-bit-rate packet data. The improved voice capacity is intended to serve existing voice demand with less of the carrier capacity than was previously required, thus making "room" for the new packet data capability. It should also be noted that the high-speed data signal is shared among many users using multiple-access techniques and thus must not be viewed as an average bit rate available to each subscriber. The actual average rate supported per user will be much less than the peak rate of 144 kbps, and probably in the range of a few tens of kilobits per second.

Appendix C – ATM service classes and functions

The Asynchronous Transfer Mode ("ATM") standards define a range of service categories. The lowest level of service, and that usually supported in common asymmetric digital subscriber line ("ADSL") implementations, is known as Unspecified Bit Rate ("UBR"). This is sometimes known as a "best-effort" service and carries with it no service quality guarantees. UBR cells carry the lowest priority in an ATM network. Thus, for example, the effective data transmission rate and the delays packets encounter as they travel through the network can and will vary, and the underlying service provider, makes no guarantee regarding the variation of either rate or delay. UBR is useful for applications such as casual Internet access in which variable cell delays are not critical and which do not require quality of service guarantees. It is unsuitable for packet voice, video, circuit emulation (such as DS-1 service) or other more sophisticated applications.

Other ATM service categories include, for example, real-time Variable Bit Rate ("rt-VBR"), which is designed to support such services as packet-switched voice communications. Voice service is particularly sensitive to end-to-end delays in transmission as well as to variations in the end-to-end delay. Excessive delay can lead to "echoes" over a circuit which can be disorienting if the delay is sufficiently long, and unacceptable variations in delay can lead to difficulties in reconstructing the analog signal at the destination. The rt-VBR service category is designed to support such delay-sensitive applications and carries with it service guarantees that ensure a suitable quality of service for them. ATM, in combination with ADSL and other forms of DSL, can thus readily support packet voice and other advanced services in addition to the relatively simple Internet access. If, for example, an incumbent local exchange carrier ("ILEC") were to make rt-VBR available to competitive local exchange carriers ("CLECs") under suitable rate elements (which would necessarily specify the ATM quality of service parameters required for these higher-level service classes), competitors could offer high-quality packetized voice service over DSL connections. A competitor could also offer advanced video services using ATM service categories with guaranteed quality of service levels.

ATM is a connection-oriented fast packet switching technology and requires a logical association, or virtual channel, between the endpoints of the connection. The term "virtual" is key in this context. Once the virtual channel is established, the network then knows to send all packets generated at one end point to the other end point in the virtual connection. The virtual circuit is just the association of the endpoints of the connection and does not imply anything about network capacity. All packet switching systems make capacity available only on demand. Thus, there is no capacity dedicated to the virtual connection as there is in the physical connection in the circuit-switched case. The most common implementation of ATM virtual channels is the permanent virtual channel ("PVC"). A PVC must be administered; that is, it is set up and removed by a network administrator using a suitable operations support service ("OSS") terminal. A PVC is generally established over a long period, typically months or even years, hence the adjective "permanent." The PVC is the basis for the "always on" feature often mentioned in conjunction with ADSL service. Because the virtual circuit is permanently assigned, the user does not have to invoke a call setup procedure each time the user wants to communicate with, for example, his or her Internet service provider. Because bandwidth is not dedicated to the PVC, the permanent nature of the virtual connection does not reduce overall network capacity when the user is idle.

ATM also allows for virtual path connections. A virtual path contains a number of virtual channels; a Permanent Virtual Path ("PVP"), for example, can contain several PVCs. PVPs are useful for managing resources. If an ILEC has made PVP connections available to a CLEC, a CLEC can lease PVPs, with associated service categories, and then administer its own PVCs within the PVPs to facilitate serving its subscribers without relying on the underlying carrier for PVC provisioning for individual users.

ILECs, however, have chosen to restrict the ATM service class available on DLC-based ADSL to the lowest, UBR, which by definition has no quality of service guarantees and which is not suitable for end-user services beyond such basic ones as email access and Web browsing. They similarly do not offer PVPs on DLC-based ADSL, thus requiring CLECs to rely entirely on ILEC provisioning and service order processes. SBC Communications, Inc. (SBC"), for example, launched Project Pronto in 2000 in an attempt to upgrade DLC systems in SBC's BOC subsidiaries to support ADSL. In the announcement process, SBC made much of their plans for allowing CLEC access to their DLC-based ADSL services.

But what was to be made available to the CLECs under Project Pronto was quite modest: UBR service and single PVCs, with an explicit exclusion of PVPs.[1] Qwest has a similarly restrictive DLC-based ADSL service that also offers only UBR to CLECs, with no PVP capability associated with the ADSL service.[2]

[1] For a representative SBC Project Pronto service description for CLECs, see "New Product Announcement Wholesale Broadband Service – California," CLECC00-138, Pacific Bell, May 24, 2000, with specific restrictions concerning ATM class of service and PVPs at p 10, section 9.6.
[2] "Qwest DSL Services," Qwest Communications International, Inc., Technical Publication 77392, Issue I, September, 2001.

HAI Consulting, Inc.

Statement of Qualifications

General Qualifications

HAI Consulting, Inc. (formerly Hatfield Associates, Inc.) is an interdisciplinary consulting and research firm serving a wide range of clients with stakes in the telecommunications field. Hatfield Associates was founded in February, 1982. With the departure of Dale Hatfield to the FCC in 1997, the remaining associates formed HAI Consulting, Inc. HAI and Hatfield Associates have provided consulting and educational services in nearly all aspects of the present and future telecommunications infrastructure, including local exchange networks, cable television systems, competitive access networks, land mobile and personal communications, long haul terrestrial and satellite communications, data communications, and customer premises equipment.

Principals of the firm include consultants with graduate degrees and decades of senior level experience in engineering, economics, business, and policy/regulation. HAI's services include, among others, regulatory filings and policy studies, engineering studies, expert testimony, market research, economic studies and cost modeling, "due diligence" support, business planning, education and system development. The firm has substantive experience in international telecommunication matters. Consulting and educational services are performed for private and public sector clients in Australia, Canada, Mexico, Chile, New Zealand and several countries in Central and Eastern Europe.

Examples of recent consulting assignments include:

- Development of a widely used cost model to estimate the investments and expenses associated with the provision of local exchange and exchange access and interconnection services;
- Analyzing the potential for competitive entry into the local exchange telecommunications business, presented in papers entitled "The Enduring Local Bottleneck: Monopoly Power and the Local Exchange Carriers" and "The Enduring Local Bottleneck II";
- Testifying in state proceedings on various aspects of competitive entry into local exchange and exchange access services, and on state mechanisms to fund universal service;
- Developing an economic and engineering analysis of the potential of broadband deployment and the role it will play in the national economy, presented in a paper entitled “Economics and Technology of Broadband Deployment.”
- Assessing the technological and economic merits of various telephone companies' plans for offering video dialtone services;

- Modeling the cost of telephone service in Mexico;
- Testifying and filing written testimony in proceedings before the Canadian Radio-telephone and Telecommunications Commission on local telephone competition, interconnection, collocation and number portability;
- Representing clients in U.S. state commission-sponsored negotiations to resolve local interconnection and number portability issues;
- Developing a vision statement dealing with the future of cable television networks in providing telecommunications and enhanced video services;
- Authoring the "Telecommunications Technology" and "Utility Applications of Telecommunications" chapters, describing utility opportunities in telecommunications, of a major telecommunications report for the Electric Power Research Institute;
- Analyzing telecommunications opportunities, costs, and modes of entry for several major electric utilities, leading in one case to a decision by the utility to deploy a backbone fiber optics network and partner with other entities in the provision of Personal Communications Services;
- Developing material on telecommunications technology for inclusion in a report on international telecommunications prepared by the Office of Technology Assessment of the U.S. Congress;
- Analyzing trends in telecommunications architectures and technologies for a major computer company;
- Providing tactical advice and computer network support for a client bidding in the FCC auction of 900 MHz Specialized Mobile Radio licenses;
- Assisting a client in the preparation of comments in an FCC proceeding dealing with the future of the private land mobile radio services;
- Assessing opportunities for the branches of the U.S. Military to consolidate their use of wireless communications;
- Providing analyses for an investment firm contemplating a major investment in a paging company; and
- Providing telecommunications education to countries in Central and Eastern Europe.

Richard A. Chandler
Senior Vice President

Richard A. Chandler is a senior vice president with HAI Consulting, Inc., where he performs a range of consulting services for clients, including evaluation of various communication technologies to address specific user requirements, review of large corporate network structures and operations, as well as the evaluation of the suitability of new products for particular markets. Among other assignments as a consultant, he has developed the technical plan for a proposed wireless-based telecommunications system to provide basic internal telephone service as well as international connectivity to the populace of a developing nation. He has worked with a Korean international carrier in the development of the technical and operating plan for a proposed Korean PCS network. Other contracts have involved the development of regional and nationwide architectures for mobile data networks and evaluation of voice compression and automated conferencing systems to support both internal and external investment decisions. He has worked extensively in the wireless communication area, studying Personal Communications Network architectural issues, including radio segment structures, backhaul networks, and interconnection issues for several clients. Most recently, Mr. Chandler has developed sophisticated telecommunications network models for use in determining the costs of telephone service, including local and toll; he has been the principal developer of the Hatfield and HAI Models commissioned by MCI WorldCom and AT&T Corp. for use at the state and national levels in supporting interconnection and universal service filings. He has also written numerous affidavits and declarations dealing with various telecommunications technologies in several regulatory and court proceedings.

Before joining Hatfield Associates (now HAI Consulting, Inc.) in 1986, Mr. Chandler joined Skylink Corporation as Vice President Network Engineering. While at Skylink, Mr. Chandler developed the ground system control and switching architecture and user terminal requirements for the proposed Skylink network. He developed a distributed control structure which allowed for the decentralization of system intelligence, enabling the simultaneous operation of multiple independent subnetworks. He also developed a packet switching mechanism for the network which enables hundreds of interactive users to share a single radio channel for data transmission. He worked jointly with mobile radio and satellite earth station manufacturers to develop preliminary ground terminal and user terminal functional requirements and technical specifications.

Mr. Chandler joined the AT&T marketing organization in 1981, where he initially was a product manager for data switching and adjunct processor enhancements for existing PBX products. In this capacity, he was responsible for coordinating design, development, and manufacturing efforts, developing business case inputs for product pricing, and coordinating training and advertising for the new products. In another assignment within this organization, he developed product strategies for advanced data switching technologies, including adjunct packet switches for customer data. He also headed a group furnishing technical support regarding product architecture and features to the AT&T field sales force and providing customer requirements to the development and product management organizations.

In 1977, Mr. Chandler joined Bell Telephone Laboratories, where he participated in exploratory studies of new PBX systems for AT&T. These investigations included the review of various switching system architectures and control structures for next-generation private branch exchanges. He designed and developed segments of a laboratory model of a new PBX and coordinated designs and interfaces for the production version of the new machine. He also studied design approaches and circuit modifications to enhance the reliability of new switching systems. In another significant assignment, he worked on packet switching techniques to be applied to a multi-processor control structure, and he participated in the development of specific packet switch designs to be applied as an adjunct to the circuit-switched network fabric for the purpose of switching user terminal-to-host and host-to-host data traffic.

From 1972 to 1977, Mr. Chandler was an electronic engineer with the Institute for Telecommunication Sciences, a telecommunications research organization within the U.S. Department of Commerce. While at ITS, he performed microwave propagation studies for atmospheric paths in the 60 GHz region, and he developed experiments for studies of space-to-earth paths at 20 GHz and 30 GHz. He also designed experiments and associated instrumentation for availability studies of short atmospheric optical paths in the near infrared. In addition, he participated in and coauthored an extensive review of existing and future cable television technology. He managed a project for the U. S. Department of Transportation for the evaluation of the applicability of tracking radar techniques to vehicular braking systems, and he managed a consulting contract with the National Oceanic and Atmospheric Administration for the technical evaluation of various commercial microwave positioning systems used in hydrographic surveying.

Mr. Chandler received B.S. and M.S. degrees in electrical engineering from the University of Missouri and an M.B.A. from the University of Denver. He pursued additional graduate work in electrical engineering at the University of Colorado. He serves as an adjunct faculty member at the University of Colorado and the University of Denver and teaches graduate-level courses in telecommunications technology, including wireless and cellular communications and digital switching and transmission.

A. Daniel Kelley
Senior Vice President

Dr. Kelley specializes in economics and public policy analysis for long distance, competitive local exchange, mobile communications, and cable television clients. Since joining HAI in 1990, he has been involved in antitrust and regulatory investigations that address cost allocation, cross subsidy, and dominant firm pricing. He has authored or co-authored papers submitted in the Federal Communications Commission's Video Dialtone, Advanced Intelligent Network, and Cable Rate Regulation proceedings. In addition, he has advised clients on the Computer III, Open Network Architecture, Access Transport Competition, Price Cap, and Local Interconnection proceedings. Dr. Kelley has provided expert testimony on competition, cross subsidy, interconnection and universal service issues before the Federal Communications Commission and the California, Colorado, Connecticut, Florida, Georgia, Hawaii, Maryland, Massachusetts, Michigan, Oregon, New Jersey, and New York Public Utility Commissions.

His international experience includes advising the governments of Chile and Hungary on competition and privatization and advising private U.S. corporations on competition and interconnection issues in Mexico and New Zealand. Dr. Kelley has participated in State Department sponsored seminars and University level instructional courses in the Czech Republic, Hungary, Poland, the Slovak Republic and Slovenia.

Prior to joining HAI in 1990, Dr. Kelley was Director of Regulatory Policy at MCI Communications Corporation. At MCI he was responsible for developing and implementing public policy positions on the entire spectrum of regulatory and legislative issues facing the company. Matters in which he was involved included the MFJ Triennial Review, Congressional Hearings on lifting the Bell Operating Company Line of Business restrictions, Tariff 12, Dominant Carrier Regulation, Local Exchange Carrier Price Caps, and Open Network Architecture. He also managed an interdisciplinary group of economists, engineers and lawyers engaged in analyzing AT&T and local telephone company tariffs.

Dr. Kelley was Senior Economist and Project Manager with ICF, Inc., a Washington, D.C. public policy consulting firm, from 1982-1984. His telecommunications and antitrust projects included analysis of the competitive effects of AT&T's long distance rate structures, forecasting long distance telephone rates, analysis of the FCC's Financial Interest and Syndication Rules, and competitive analysis of mergers, acquisitions and business practices in a variety of industries.

From January 1978 to September 1982, Dr. Kelley was with the Federal Communications Commission. At the FCC he served as Special Assistant to Chairman Charles D. Ferris. As Special Assistant, he advised the Chairman on proposed regulatory changes in the broadcasting, cable television and telephone industries, analyzed legislation and drafted Congressional testimony, and coordinated Bureau and Office efforts on major common carrier matters such as the Second Computer Inquiry and the Competitive Carrier Rulemaking. He also held Senior Economist positions in the Office of Plans and Policy and the Common Carrier Bureau.

Dr. Kelley was a staff economist with the Antitrust Division, U.S. Department of Justice, from September 1972 to January 1978. At the Justice Department he analyzed competitive effects of mergers and business practices in the cable television, broadcasting, motion picture, newspaper and telephone industries. As a member of the economic staff of U.S. v. AT&T, he was responsible for analyzing proposals for restructuring of the Bell System.

Dr. Kelley received a Ph.D. in Economics from the University of Oregon in 1976, with fields of specialization in Industrial Organization, Public Finance and Monetary Theory. He also holds an M.A. in Economics from the University of Oregon and a B.A. in Economics from the University of Colorado. He has published numerous articles on telecommunications economics and public policy and regularly participates as a speaker at academic and industry conferences.

David M. Nugent
Associate

Mr. Nugent participates in a wide range of HAI consulting projects. He specializes in quantitative analysis and complex cost modeling related to these projects. Since joining HAI, Mr. Nugent has played an active role in the development of the HAI Model. Recently, he was responsible for the development and implementation of an algorithm that computes efficient ring systems from a data set consisting of known wire center locations. This algorithm was incorporated into the HAI Model 5.0, where it is used to compute interoffice network facility distances. Outside of development work, Mr. Nugent has used the HAI Model to conduct a number of specialized analyses for a variety of clients.

In addition to his experience with the HAI Model, Mr. Nugent co-authored an engineering-economic analysis addressing the potential for facilities-based competition in the local exchange market. This analysis considered cable telephony and wireless local loops as alternative local access technologies. Mr. Nugent focused on the cable telephony portions of the study where he evaluated the status of existing cable systems, the cost of network upgrades, cable telephony revenue opportunities, and the availability of cable telephony equipment.

Mr. Nugent participated in an evaluation of Local Multipoint Distribution Service (LMDS) as a broadband access technology. Although this analysis considered the regulatory and economic aspects of LMDS, Mr. Nugent's responsibilities revolved around the technology of LMDS, where he examined system capacity, hardware, and the cost associated with the network buildout.

Mr. Nugent has played key roles in a number of additional projects including the estimation of damages in several class action lawsuits. Mr. Nugent also participated in the FCC's simultaneous multiple round auction for the sale of 900 MHz spectrum. His responsibilities included the configuration of a remote bidding system and the design of auction analysis and tracking tools.

Before joining Hatfield Associates, Mr. Nugent was a programmer/analyst with American Electric Power. At AEP he was responsible for drafting specifications and coding data acquisition systems used in support of a nuclear generating facility. The majority of Mr. Nugent's time was devoted to writing specifications for real-time plant monitoring systems.

Mr. Nugent is a Summa Cum Laude graduate of Ohio University and holds a B.S. degree in Computer Science. He also holds an M.S. degree in Telecommunications from the University of Colorado.